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Renewable Energy Snapshots 2013

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PREFACE

The European Council endorsed at its Meeting in Brussels on 8/9 March 2007 a binding target of a 20% share of renewable energies in the overall EU energy consumption by 2020 and a 10% binding minimum target to be achieved by all Member States for the share of biofuels in overall EU transport petrol and diesel consumption.

The 2009 Directive on the "Promotion of the use of energy from renewable sources" not only set the mandatory targets for the European Union's Member States, but also drafted a trajectory how to reach the targets for each of them.

A total of about 45 GW of new power capacity was constructed in the EU last year[1] and 12.5 GW were decommissioned, resulting in 32.5 GW of new net capacity. Solar photovoltaic systems accounted for 16.8 GW, or 37% of the newly installed capacity. Wind moved to the second place with 11.9 GW (26%), followed by10.5 GW (23%) gas fired power stations; 3 GW (7%) MW coal-fired power stations; 1.3 GW (3%) biomass; 833 MW (1.8%) STE and 424 MW (> 1%) hydro. The net installation capacity for oil-fired, coal fired and nuclear power plants was negative, with a decrease of 3.2 GW, 2.3 GW and 1.2 GW respectively. The renewable share of new power installations was 70% in 2012. In terms of net capacity, renewable power addition accounted even for 85%.

Renewable Energies are a very dynamic field with high growth rates and therefore, it is of great importance to base decisions on the latest information available as otherwise important development trends might be missed. For certain renewable energy technologies the development of effective policy measures is not yet possible due to the lack of robust, consistent and up to date data.

These Renewable Energy Snapshots are based on various data providers including *data from grey literature*[2] and tries to give an overview about the latest developments and trends in the different technologies. Due to the fact that unconsolidated data are used there is an uncertainty margin which should not be neglected. We have cross checked and validated the different data against each other's, but do not take any responsibility about the use of these data. Nevertheless, we try to update the data as frequent as possible and would be most grateful for any update of information, if outdated or incorrect information are observed.

Ispra, June 2013

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1 EWEA, Wind in power – 2012 European statistics, February 2013 and data in the Snapshots

2 **Grey literature** is informally published written material (such as reports) that may be difficult to trace via conventional channels such as published journals and monographs because it is not published commercially or is not widely accessible. It may nonetheless be an important source of information for researchers, because it tends to be original and recent. Examples of grey literature include patents, technical reports from government agencies or scientific research groups, working papers from research groups or committees, white papers, and preprints.

TABLE OF CONTENT

BIOELECTRICITY

a. Installed capacity

The total installed capacity of electricity power plants possible to be fed with raw material of renewable origin was 28.7 GW in 2010 and reached 31.3 GW in 2011. Nevertheless, this total installed capacity figure also includes Municipal waste treatment facilities that are usually fed with a mixture of renewable and non-renewable material and in Figure 1 this capacity is shown separately. The overall bioelectricity installed capacity has shown in the last decade an average annual increase of about 2 GW per year i.e., more than four times the annual average increase in installed capacity between 1996 and 2002 (which was around 450 MW/y).

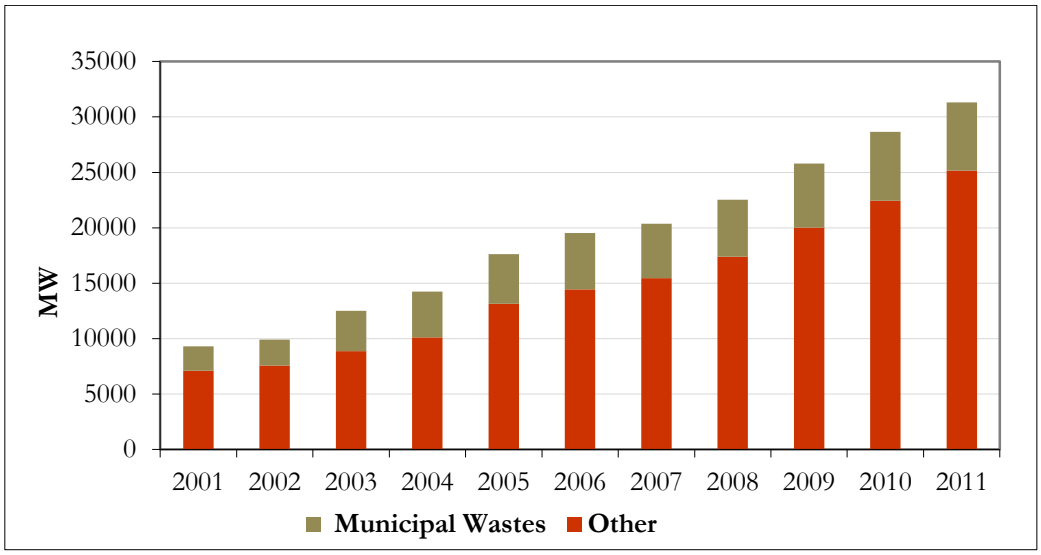

Figure 1 Total bioelectricity installed capacity in the EU-27 from 2001 to 2011.

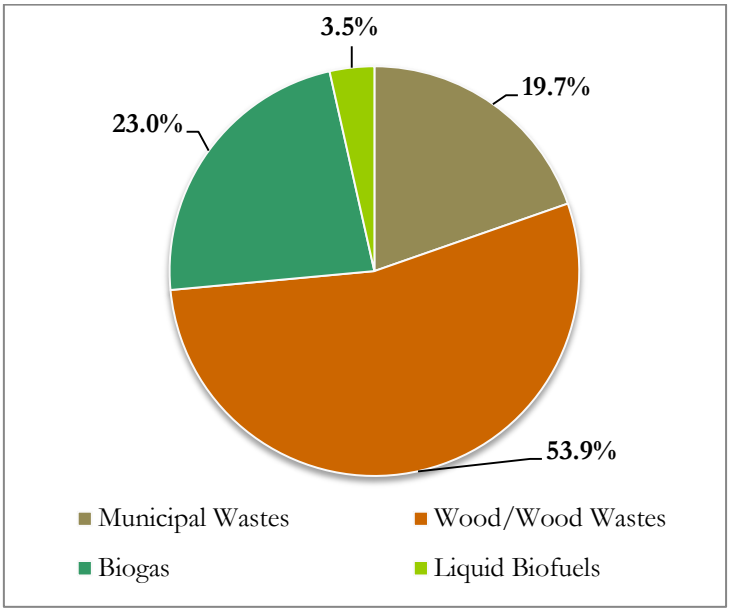

Figure 2 Installed bioelectricity capacity by source in the EU-27 in 2011

Wood/wood waste represents the biggest proportion of installed capacity with 53.9 % (Figure 2) but biogas is the sector that has shown the highest percent growth rate in 2011 comparing with 2010 data: 17% of growth to be compared with 10% of wood and 8% for liquid biofuels. Municipal waste has shown a slight decrease in the installed capacity in 2011, with -1% (about – 40 MW)

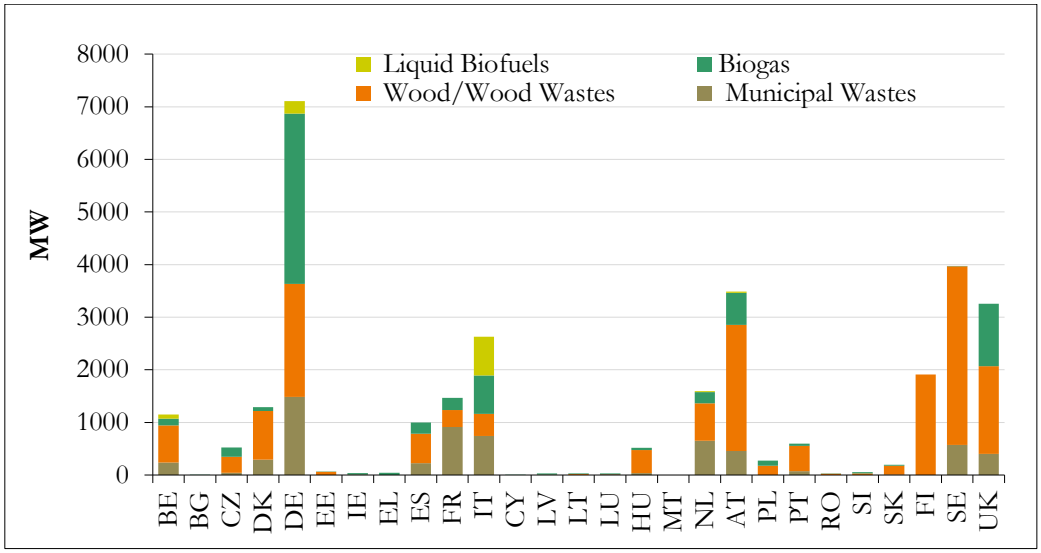

Figure 3 Bioelectricity installed capacity in the EU MS-s by source in 2011

Wood and wood waste is mostly processed in 4 leading countries (Sweden, Germany, Austria and Finland) accounting for more almost 10 GW in total. Germany is also leader for electricity from biogas with 3.2 GW installed, followed by UK (1.2 GW) Italy and Austria (730 MW and 600 MW respectively).

b. Electricity generated

The electricity produced originating from biomass was 123 TWh in 2010 and 133 TWh in 2011 in the EU-27 with yearly increases between 10 % and 20% in the last decade. (Figure 4).

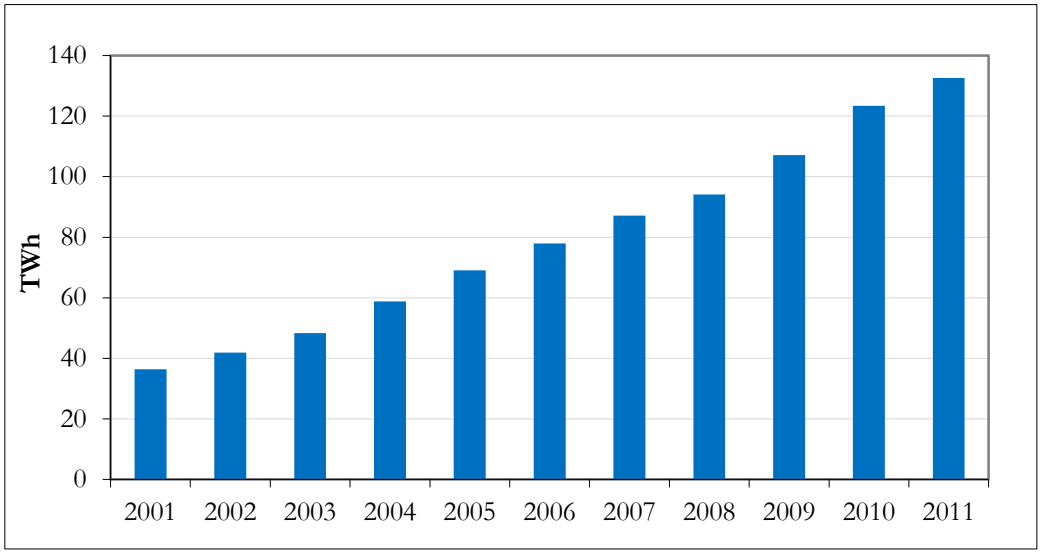

Figure 4 Bioelectricity production in the EU-27 since 2001.

Germany kept its role as the biggest bioelectricity producer in 2011 with 37.6 TWh followed by Sweden and UK with 13 TWh and 12.5 TWh respectively (Figure 5). These three countries alone represent almost half (47 %) of the total production within the EU-27 Member States.

Wood and wood waste was also the main source of generated electricity with a proportion of 55.4 % followed by biogas (27.2 %) while the renewable fraction of municipal waste accounted for 13.8 % (Figure 6).

For more than half (16) of the member states the wood/ wood waste was the leading bioelectricity source, while in a smaller number of countries (Germany, Ireland, Greece, Luxembourg, UK and Latvia) biogas is the leading source of bioelectricity. .

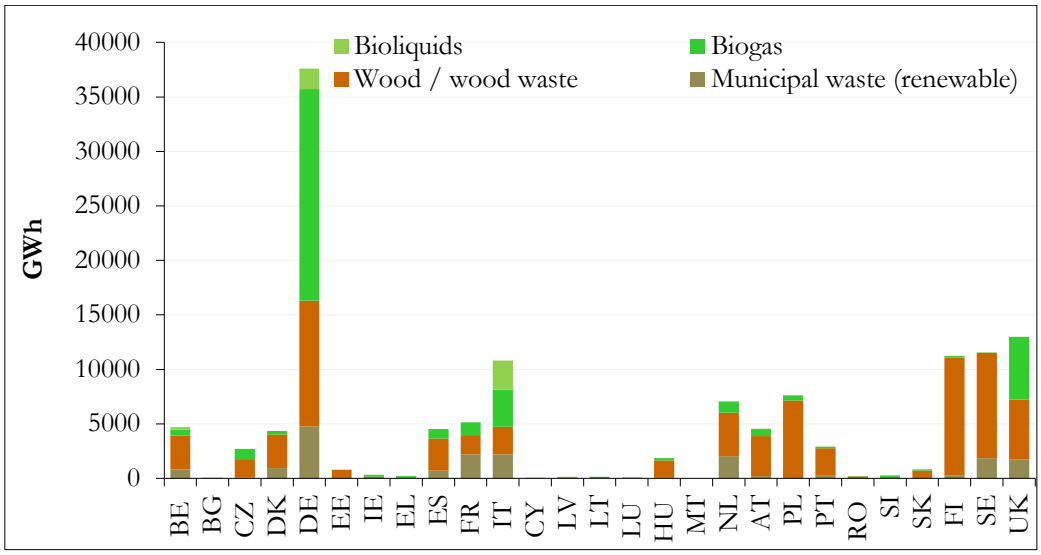

Figure 5 Bioelectricity production in the EU-27 Member States in 2011 by sources

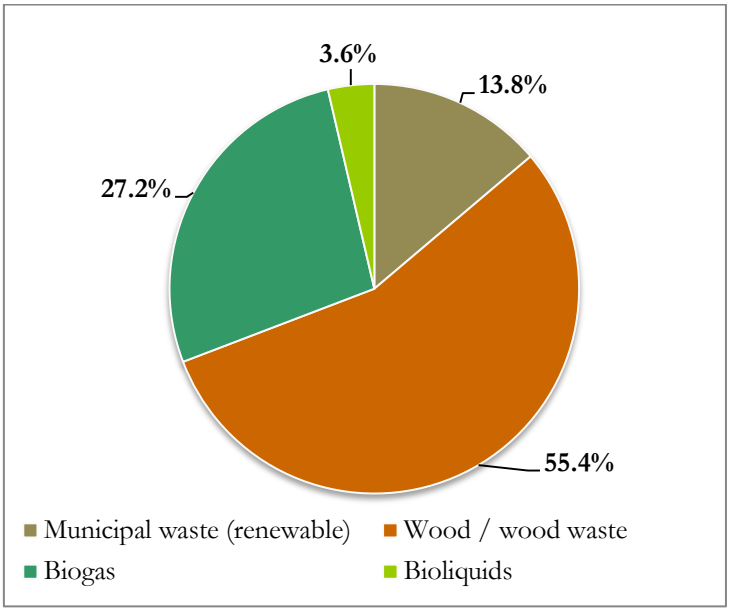

Figure 6 Bioelectricity generation from biomass in the EU-27 in 2011 by source

Comparing data on electricity production with electricity installed capacity, it is possible to evaluate the equivalent value Full Load Hours for bioelectricity in EU-27: the average value of this parameter during last 10 years in EU-27 amounted to about 4100 hours if only the renewable fraction on Municipal waste is considered while this number increases to about 4700 hours when

all waste sources are considered. Detailing by source, biogas has shown around 4900 Full Load Hours, while about 4400 Full Load Hours are associated with wood/wood waste and 4200 with liquid biofuels.

HEAT FROM BIOMASS

Heat produced from biomass amounted to 9.7 Mtoe in 2010 and 9.6 Mtoe in 2011 in the EU-27 (Figure 7).

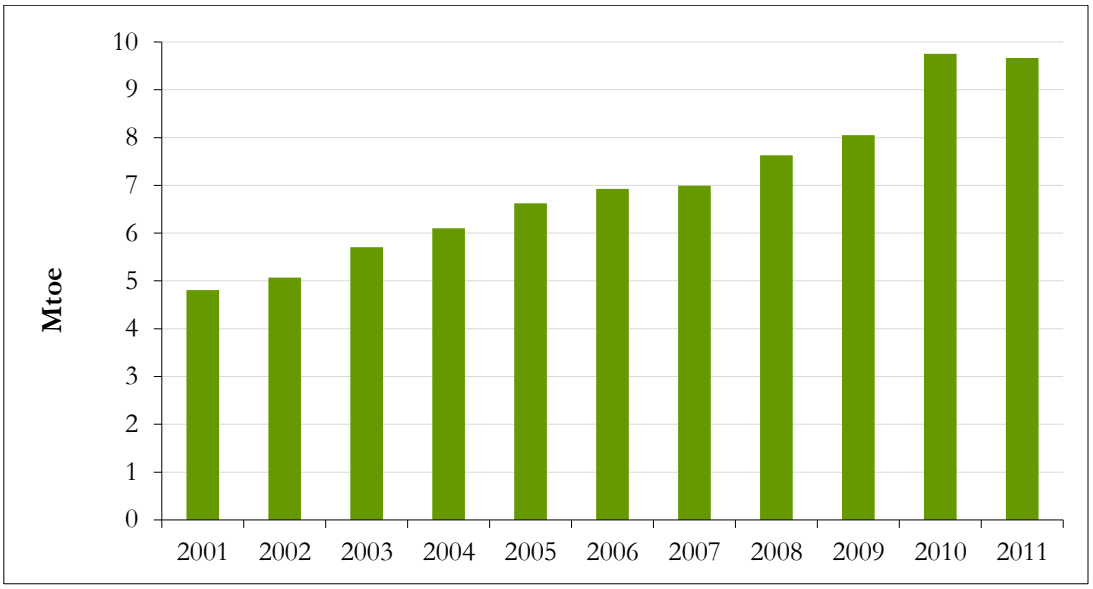

Figure 7 Heat production from biomass in the EU-27 since 2001

The solid forms of biomass are by far the main sources for heat production from biomass in the EU-27 with wood and wood waste accounting for 75 % of the heat generated. (Figure 8). Sweden was the leading member state in bioheat production with 2.5 Mtoe, followed by Finland, Denmark and Germany with 1.5 Mtoe 1.2 Mtoe and 1 Mtoe, respectively (Figure 9). These four countries covered around 66 % of the total EU-27 bioheat production.

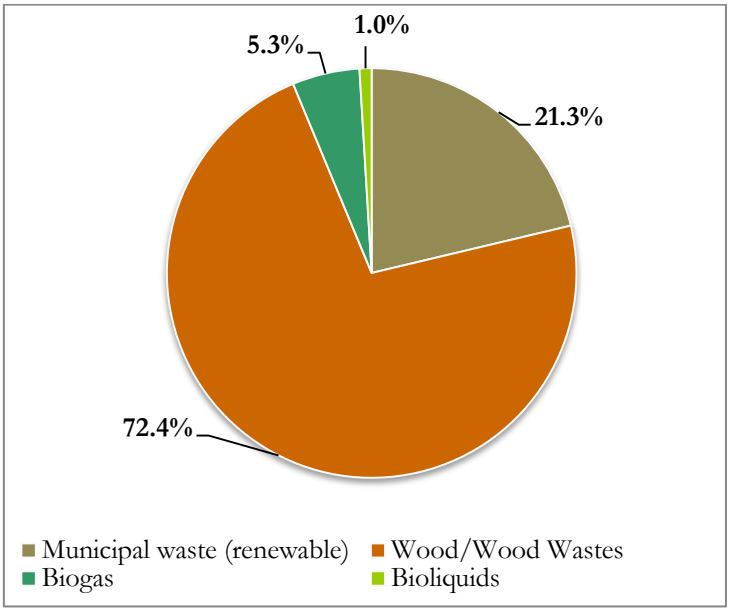

Figure 8 Bioheat production by source in the EU-27 in 2011

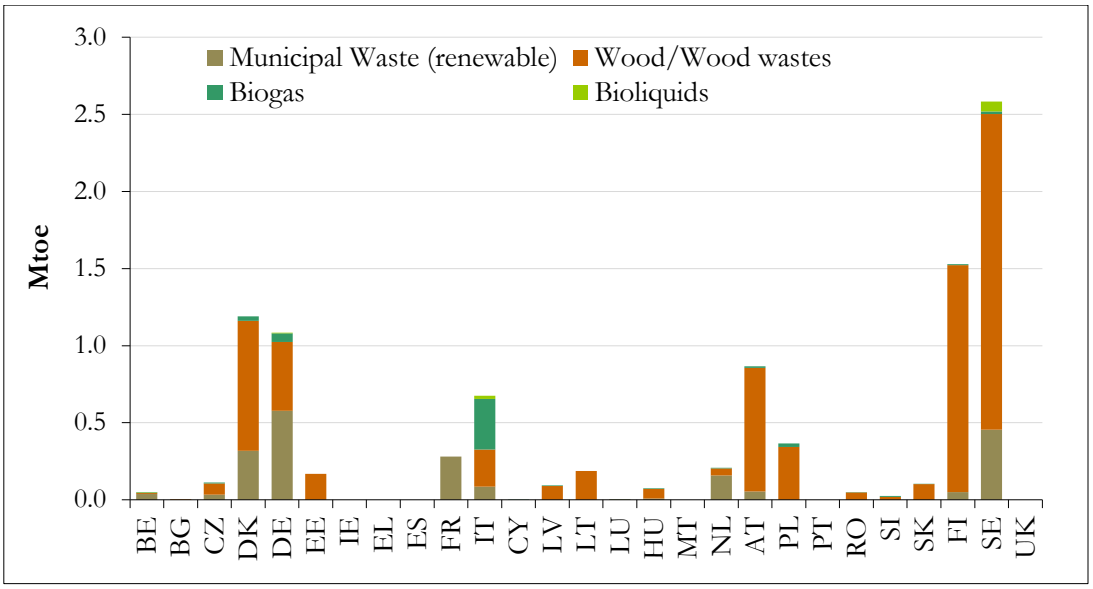

Figure 9 Bioheat production by sources in the EU-27 Member States in 2011

BIOFUELS: SOURCES AND USE

Primary production of biofuels in EU-27 amounted to a total of 11.5 Mtoe in 2011. The majority of the produced biofuels is biodiesel (71%) while biogasoline and other liquid biofuels contributed less (15% and 14%, respectively). Imported biofuels provided 6.4 Mtoe while 2.4 Mtoe of biofuels was exported in 2010 summing to a net import balance of 2.6 Mtoe. Table 1 summarizes the total flows of liquid biofuels in EU-27 in 2010.[3]

Table 1: Biofuels flows in EU-27 in 2011. Data in ktoe. (Eurostat 2013)[4] [5]

	Biogasoline	Biodiesel	Other liquid biofuels	Total
Primary production	**1751**	**8112**	**1592**	**11455**
Total imports	1595	4537	226	6358
Stock change	-22	-73	1	-94
Total exports	419	1919	28	2366
Net imports	**1176**	**2618**	**198**	**3992**
Gross inland consumption	**2905**	**10755**	**1792**	**15452**
Input to lthermal power stations	0	0	877	877
Input to district heating plants	0	0	88	88
Final energy consumption	**2897**	**10678**	**813**	**14388**
Final energy consumption-Industry	0	18	273	291
Final energy consumption -Transport	2892	10644	422	13958
Final energy consumption -Households/Services	5	16	118	139
Statistical Difference	**8**	**77**	**14**	**99**

[3] The not negligible statistical difference for some products shows how 2011 data still needed stabilization at the time of last update (May 2013)

[4] In the whole analysis the following biofuels products coded by EuroStat have been considered: biogasoline (5546), biodiesel (5547), other liquid biofuels (5548), biofuels (5545).

[5] Eurostat indicators: Primary production (100100), total imports (100300), stock change (100400), total exports (100500), net imports (100600) , gross inland consumption (100900), Input to conventional thermal power stations (101001), Input to district heating plants (101009), Final energy consumption (101700), Final energy consumption – Industry (101800), Final energy consumption – Transport (101900), Final energy consumption - Households/Services (101200)

Almost all biogasoline (i.e., the sum of bioethanol, biomethanol, bio-ETBE and bio-MTBE[6]) and biodiesel is used in transport sector, while a consistent amount of other liquid biofuels (mainly pure vegetable oils) are used for district heating, power generation and industry (see figures 6 and 8).

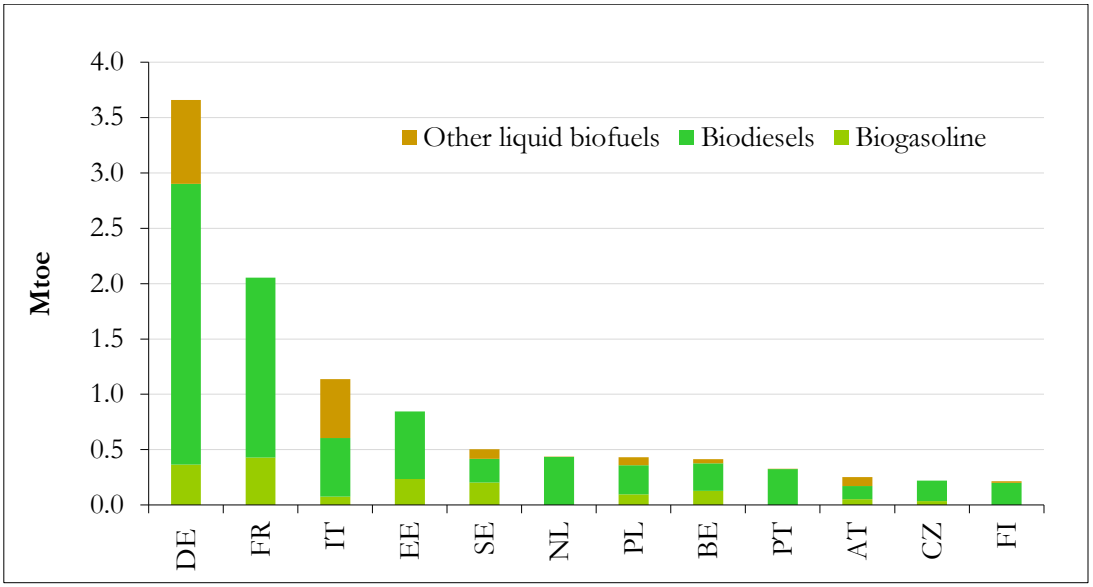

Figure 10: Relevant biofuels producers in EU-27 in 2011. Countries not included in the figure produce less than 200 ktoe[7].

In EU-27, Germany is the main biofuel producer with 3.7 Mtoe (32% of EU-27 production) followed by France with 2 Mtoe (18% of EU-27 production). Other relevant biofuels producers are shown in Figure 10.

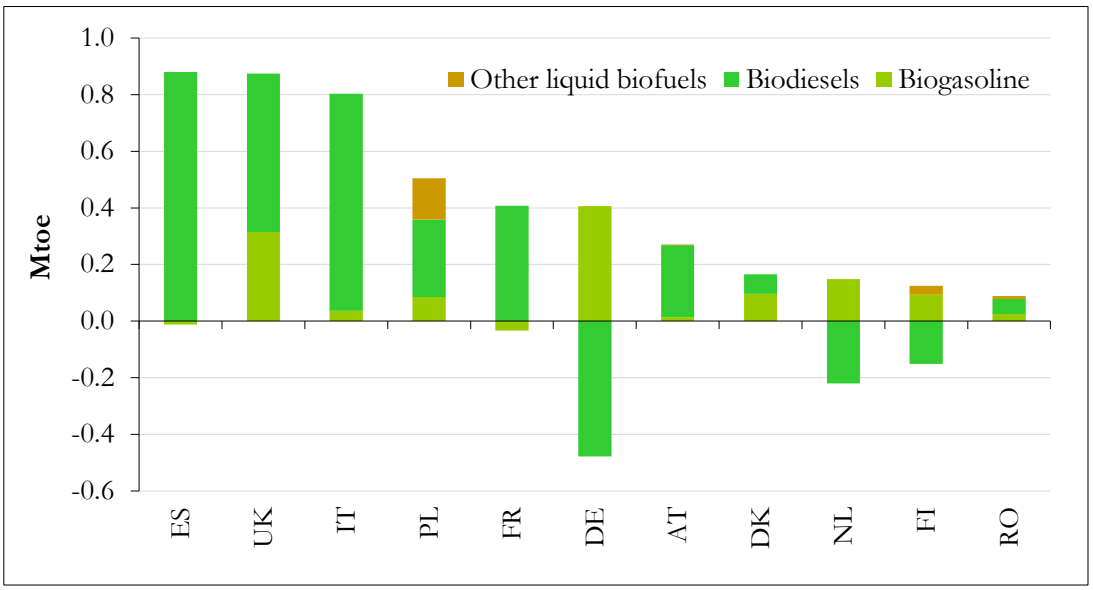

Figure 11: Relevant biofuels importers (positive values) and exporterss (negative values) in EU-27 in 2010. Countries not included in the figure import and export less than 80 ktoe[8].

[6] See Eurostat's Concepts and definition database (CODED) and definitions in Directive 2003/30/EC on the promotion of the use of biofuels and other renewable fules for transport.
[7] Eurostat indicators: Primary production (100100)
[8] Eurostat indicators: Total imports (100300), total exports (100500)

Import/export flows for EU-27 countries in 2011 are shown in Figure 11. Spain was in 2011 the main biofuel importer with 880 ktoe of biodiesel, while UK has imported 875 ktoe of biofuels, mainly biodiesel. In the case of Spain biofuels import is roughly equivalent to the domestic production while in case of UK import accounted for about 5 times the domestic production. In the large majority of EU countries, both production and import/export flows focus on biodiesel.

TRENDS IN BIOFUELS MARKET.

Figure 12 shows as the production of biofuels that has been constantly increasing in last decade showed for the first time a decrease, with 2011 production ranging in between 2008 and 2009 values. Since 2008 EU-27 became a net importer of an increasing amount of biofuels. Nevertheless, even if the consistent amount of net imports (1.5 Mtoe in 2011) is considered, the overall amount of biofuels in the EU-27 market has decreased by about 0.4 Mtoe. This is a relevant change in the tendency, as since 2007 the domestic EU-27 biofuels production had grown by roughly 10% every year. From 2007 to 2010 the annual production had steadily increased by around 1000 ktoe per year. If also imports are considered, the overall amount of marketed biofuels in EU-27 had increased in the period by around t2 Mtoe during the years 2006-2010.

On summary, latest trends show that the slowing of the recent huge market expansion for biofuels in EU-27 perceived in 2010 has turned to a sharp decrease of production, not enough compensated by a noticeable increase in the net imports.

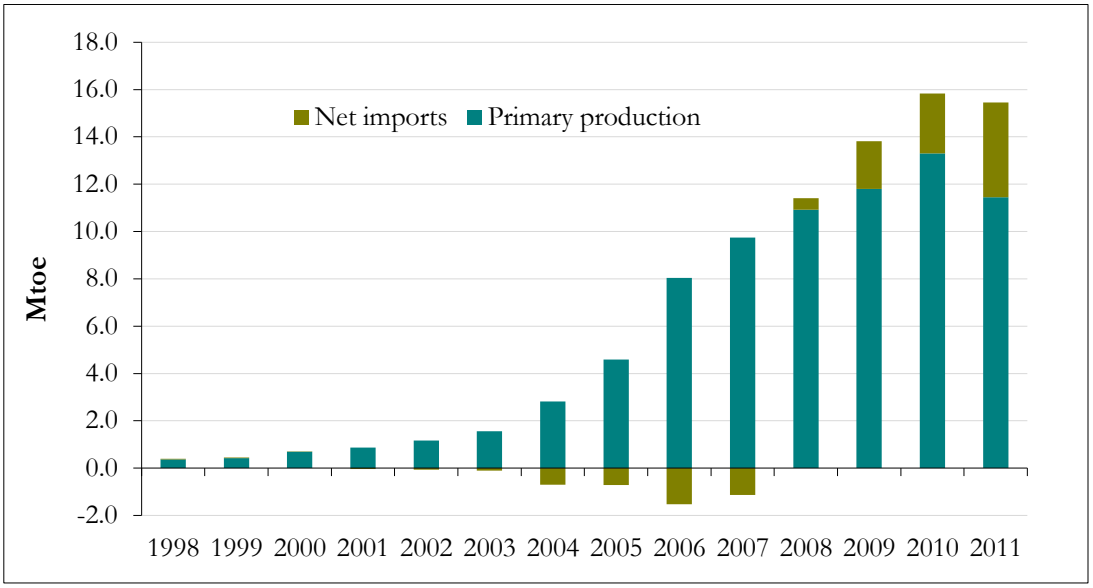

Figure 12: trends of biofuels production and imports in 1998 – 2011 in EU-27 [9].

BIOFUELS IN TRANSPORT SECTOR

The decreasing trend discussed in the previous section did not involve the transport sector, as in 2011 the **consumption of biofuels** in EU-27 in the transport sector reached 14 Mtoe from 13.3 MToe of 2010.

[9] Eurostat indicators: Primary production (100100),Total imports (100300).

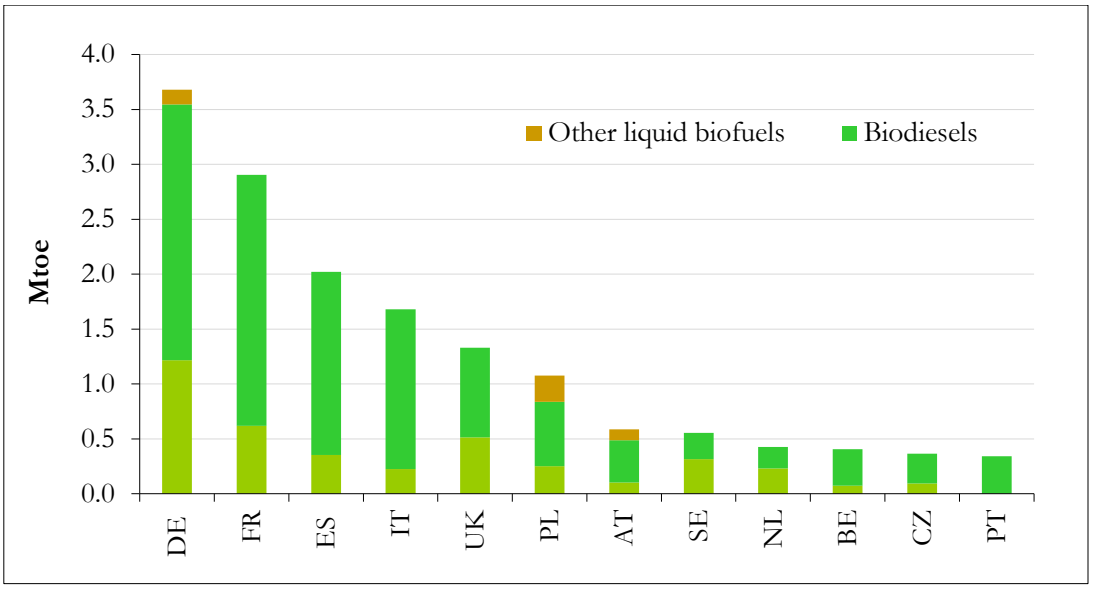

Figure 13: Final energy consumption of biofuels in the transport sector in the EU-27 in 2012 (Eurostat 2013). Countries not included in the figure consume less than 300 ktoe.[10]

Biodiesel has been by far the most consumed biofuel with a share of 76% while biogasoline accounted for 21 % and other biofuels accounting for around 3% (see Figure 13).

Germany is still the largest consumer of biofuels in EU-27 (3.7 MToe with a 22% share) followed by France: 2.9 Mtoe accounting for 17 % of EU-27 consumption. Italy, Spain and UK all have a biofuels consumption share ranging between 8 and 12 percent of the whole European market

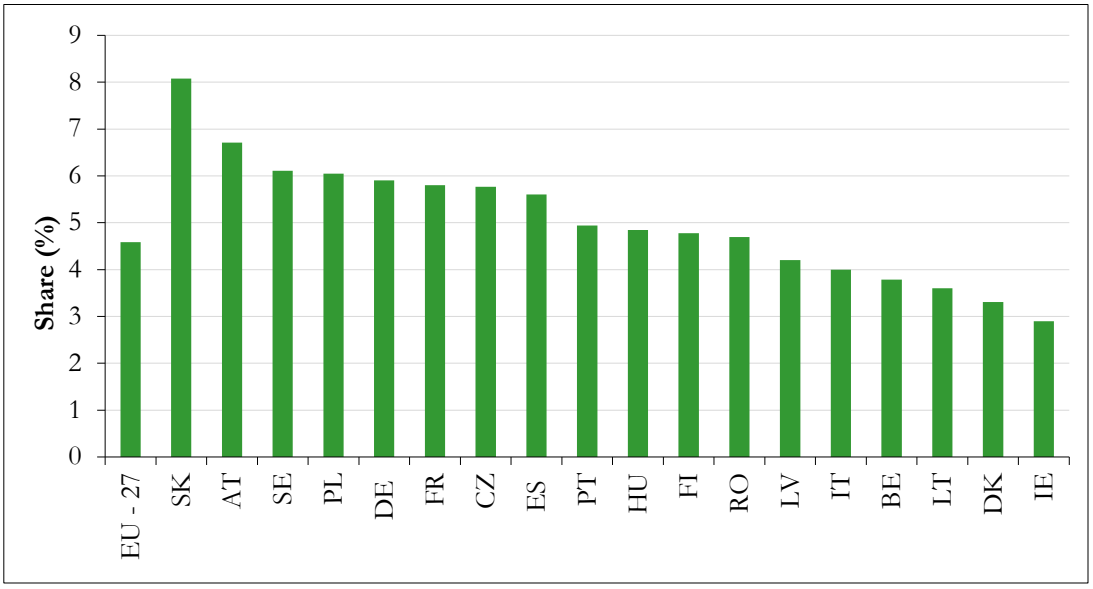

Figure 14: Share of energy consumption in transport provided by biofuels in 2010. (Eurostat 2012) Countries not shown in the figure have a biofuels share smaller than 3% [11].

Figure 14 shows the **share of biofuel contribution to the overall energy consumption in transport sector** for the EU-27 countries. On average biofuels accounted for 4.6% of the energy

[10] Eurostat indicators: Final energy consumption – Transport (101900).
[11] Eurostat indicators: Final energy consumption – Transport (101900) for all products (0000) and biogasoline (5546), biodiesel (5547), other liquid biofuels (5548).

consumed in transport in 2010 with an increase of about 0.9% in comparison with 2010 figure. Nevertheless, the situation is very diverse throughout Europe.

Slovakia (8.1%), Austria (6.7%), Sweden (6.1%), Poland (6%), France, Germany and Czech Republic (5.8%), lead the way, while all other countries are below 5%, with 9 countries not reaching the 3%, in front of a compulsory target of 10% of renewable energy in transport in 2020.

References

Eurostat 2012: Data navigation tree at http://epp.eurostat.ec.europa.eu/ last access May 2013.

CONCENTRATED SOLAR THERMAL ELECTRICITY (STE) SNAPSHOT 2013

Solar thermal electricity (STE), also known as solar electric power (STE), is generating electricity by converting concentrated solar energy to heat, which is converted to electricity in a conventional thermal power plant. The two major concepts used today are *Parabolic Trough* power plants and *Power Towers*. Other concepts including the *Dish Design* with a Stirling engine are researched as well, but so far no commercial plant has been realised.

After more than 15 years, the first new major capacities of Concentrated Solar Thermal Electricity Plants came online with Nevada One (64 MW[12], USA) and the PS 10 plant (11 MW, Spain) in the first half of 2007. In Spain the Royal Decree 661/2007 dated 25 March 2007 was a major driving force for STE plant constructions and the ambitious expansion plans between 2007 and early 2012 when the Spanish Government passed the Royal Decree 1/12 [1], which suspended the remuneration pre-assignment procedures for new renewable energy power capacity.

At the end of beginning of May 2013 STE plants with a cumulative capacity of about 2.05 GW were in commercial operation in Spain about 69% of the worldwide capacity of 2.95 GW. Together with those plants under construction and those already registered for the feed-in tariff this should bring Spain's STE capacity to about 2.3 GW by the end of 2013. In total projects with a total capacity of 15 GW have applied for interconnection. This is in line with the European Solar Industry Initiative, which aims at a cumulative installed STE capacity of 30 GW in Europe out of which 19 GW would be in Spain [2]. In the US, about 1.2 GW of STE are currently under construction and another 4.2 GW in the development stage [3]. More than 100 projects are currently in the planning phase mainly in Spain, North Africa, India and the USA.

The current STE market is dominated by the parabolic trough technology. More than 80% of the STE power plants in operation or under construction are based on this technology. As a consequence, most of the available cost information refers to parabolic trough systems. The cost data for parabolic trough systems are also the most reliable, although uncertainties still remain, because it is the most mature STE technology.

The current investment cost for parabolic trough and solar tower plants without storage are between USD 4,500/kW and USD 7,150/kW[13]. STE plants with thermal energy storage tend to be significantly more expensive, but allow higher capacity factors, the shifting of generation to when the sun does not shine and/or the ability to maximise generation at peak demand times. Figure 1 exhibits the actual price development compared to the expected price reductions following the learning curve [4].

Table 1 and 2 list the STE plants in operation and those under construction which are scheduled to become operational until 2014. If the announced schedules are kept, the current installed capacity of about 2.9 GW should be close to 5 GW at the end of 2014. The various investment costs vs. capacity ratios are shown in Figure 2.

[12] The capacity figures given are MW_{el} (electric) not MW_{th} (thermal)

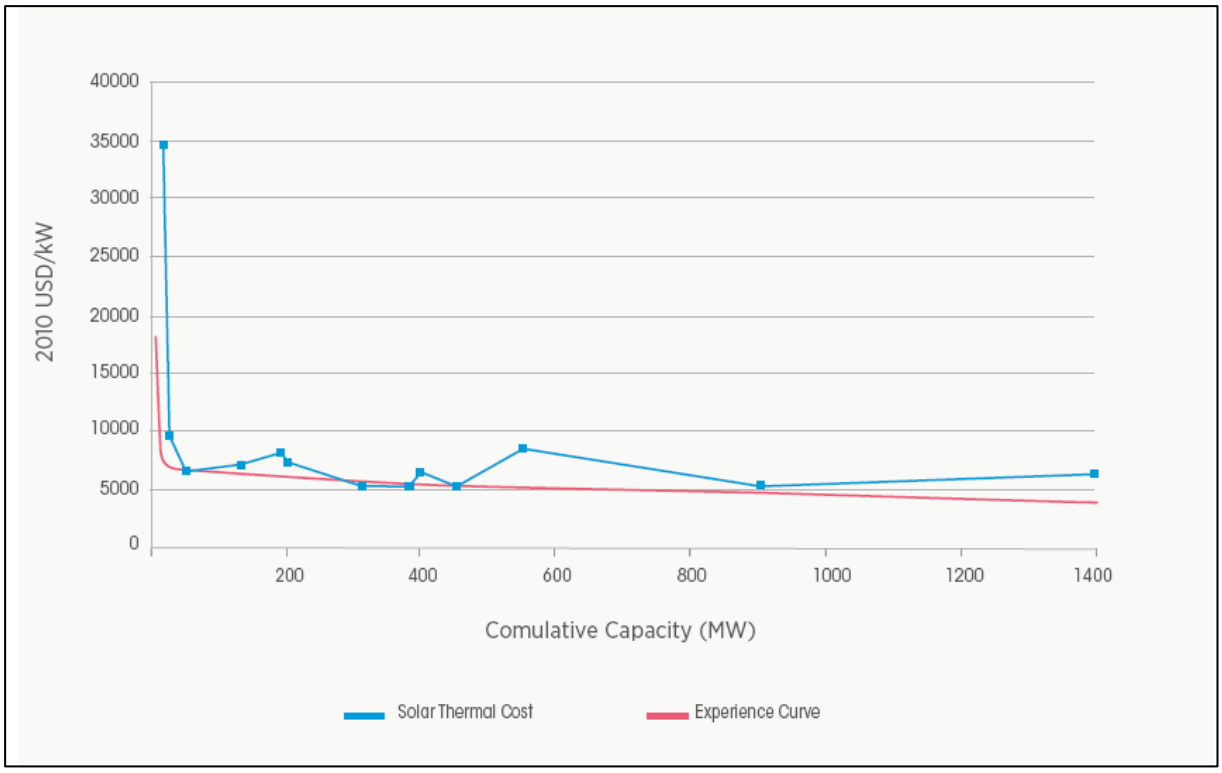

Figure 1: STE historical cost data, cumulative capacity growth and experience curve [4]

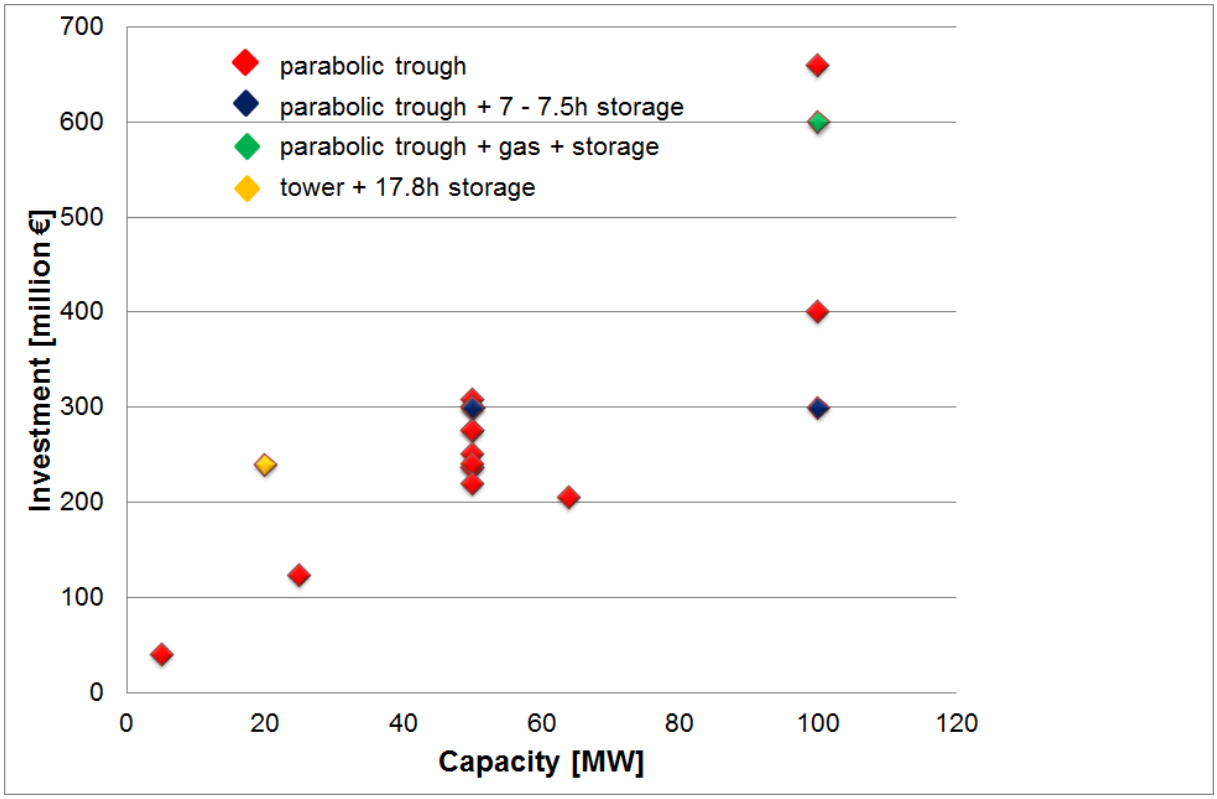

Figure 2: Investment costs of STE plants versus capacity (investment year €)

Table 1: List of plants in commercial operation [5, 6, 7]

Name of Project and Consortium	Technology	Capacity [MW_{el}]	Start of operation	Investment Volume
SEGS (Mojave Dessert, CA, USA)	parabolic troughs	354	1984 -1990	n.a.
Saguaro Solar Facility, Arizona Public Service (Red Rock, AZ, USA)	parabolic troughs	1	2006	n.a.
Nevada Solar One, Acciona/Duke Energy (Boulder City, NV, USA)	parabolic troughs	64	2007	$ 266 million
Solúcar Platform – PS 10 Abengoa; (Sanlúcar la Mayor, Spain)	tower	11	2007	n.a.
Andasol 1; Solar Millenium (Guadix, Spain)	parabolic troughs	50	2008	€ 300 million
Kimberlina Ausra; (Bakersfield, CA, USA)	fresnel reflectors	5	2008	n.a.
Liddel Power Station (Lake Liddel, Australia)	fresnel reflectors	2	2008	n.a.
Andasol 2 Solar Millenium; (Guadix, Spain)	parabolic troughs	50	2009	€ 300 million
Solúcar Platform – PS 20 Abengoa; (Sanlúcar la Mayor, Spain)	tower	20	2009	n.a.
Puertollano 1 Iberdrola; (Ciudad Real, Spain)	parabolic troughs	50	2009	n.a.
Alvarado I; Acciona (Alvardao, Badajoz, Spain)	parabolic troughs	50	2009	€ 236 million
Sierra Sun Tower eSolar; (Lancaster, CA, USA)	tower	5	2009	n.a.
Puerto Errado 1, Novatec Solar (Calasparra, Spain)	fresnel reflector	1.4	2009	n.a.
Keahole Solar Power (Hawaii, HI, USA)	parabolic troughs	2	2009	n.a.
Shiraz solar power plant, Iran	parabolic troughs	0.25	2009	n.a.
Maricopa Solar, NTR (Phoenix, AZ, USA)	dish stirling	1.5	2010	n.a.
Extresol 1 & 2; ACS-Cobra-Group/Solar	parabolic troughs	100	2010	Extresol 1,

Millenium AG (Torre de Miguel, Spain)	+ 7.5h storage			€ 300 million
Solúcar Platform – Solnova 1 ,3; 4, Abengoa/Schott Solar (Sanlúcar la Mayor, Spain)	parabolic troughs	150	2010	Solnova 1 & 3, € 400 million
Archimedes, Sicily, Italy	Gas, Solar + storage	5 solar	2010	€ 40 million
La Florida, Renovables SAMCA (Badajoz, Spain)	parabolic troughs + 7.5h storage	50	2010	n.a.
Hassi-R'mel I; Algéria (Sonartrach/Abener)	Solar Combined Cycle	150 total, 35 solar	2010	€ 320 million
Name of Project and Consortium	Technology	Capacity [MW_{el}]	Start of operation	Investment Volume
Ain-Ben-Mathar, Morocco (Abengoa/ONE)	Solar Combined Cycle	470 total, 35 solar	2010	€ 469 million
Yazd Solar Thermal Power Plant, Iran	Solar Combined Cycle	467 total 17 solar	2010	n.a.
Palma de Rio II, Acciona (Palma del Río, Spain)	parabolic troughs	50	2010	€ 251 million
Majades I, Acciona (Majadas de Tiétar, Spain)	parabolic troughs	50	2010	€ 237 million
Martin Next Generation Solar Energy Center, FPL (Indiantown, FL, USA)	ISCC	75 solar	2010	$ 480 million
La Dehesa, Renovables SAMCA (La Garrovilla, Spain)	parabolic troughs + 7.5h storage	50	2011	n.a.
Lebrija-1, Solel/Sacyr (Lebrija, Spain)	parabolic troughs	50	2011	$ 400 million
Manchasol 1 & 2, ACS/Cobra Group (Alcazar de San Juan, Spain)	parabolic troughs + 7.5h storage	100	2011	n.a.
Kuraymat; Iberdrola/Mitsui/Solar Millenium; (Kuraymat, Egypt)	Solar Combined Cycle	150 total, 25 solar	2011	solar part: 4,935 $/kW.
Gemasolar, Terresol Energy (Fuentes de Andalucía, Seville, Spain)	Solar tower with molten salt storage	20 (6,500h/a	2011	€ 240 million

Palma de Rio I, Acciona/Mitsubishi Corp. (Cordoba, Spain)	parabolic troughs	50	2011	€ 240 million
Helioenergy 1 Abengoa (Écija, Sapin)	parabolic troughs	50	2011	€ 275 million.
Andasol 3; Solar Millenium AG (Spain)	parabolic troughs; solar (90%) + gas + thermal storage	50	2011	€ 300 million
Valle 1 & 2; Torresolar (San Jose de Valle, Spain)	parabolic troughs + 7h storage	100	2011	€ 660 million
Helioenergy 2 Abengoa (Écija, Spain)	parabolic troughs	50	2011	€ 275 million
El Reboso II, Bogaris (La Puebla del Río, Spain)	parabolic troughs	50	2011	€ 220 million
Victorville 2 Victorville, CA (USA)	gas fired + parabolic troughs	553 total with 50 solar	2011	$ 450 million
ACME Solar Tower, Bikaner (Rajasthan)	Solar tower	2.5	2011	n.a.
Thai Solar Energy 1, (Huai Kachao, Kanchanaburi Province, Thailand)	parabolic troughs	5	2012	n.a.
Aste 1A & 1B1 (Alcázar de San Juan, Ciudad Real, Spain)	parabolic troughs + 8h storage	100	2012	n.a.
Puerto Errado 2 (Calasparra, Spain)	fresnel + 0.5h storage	30	2012	n.a.
Solacor 1 & 2 (El Carpio, Córdoba, Spain)	parabolic troughs	100	2012	n.a.
Helios 1 & 2 (Puerto Lapice, Ciudad Real, Spain)	parabolic troughs	100	2012	n.a.
Solaben 2 & 3 (Logrosan, Spain)	parabolic troughs	100	2012	> € 500 million
Moron (Morón de la Frontera, Sevilla, Spain)	parabolic troughs	50	2012	n.a.
Guzmán (Palma del Rio, Córdoba, Spain)	parabolic troughs	50	2012	n.a.

Name of Project and Consortium	Technology	Capacity [MW_{el}]	Start of operation	Investment Volume
La Africana (Palma de Rio, Spain)	parabolic troughs	50	2012	n.a.
Olivenza 1 (Olivenza, Spain)	parabolic troughs	50	2012	
Orellana (Orellana, Spain)	parabolic troughs	50	2012	n.a.
Extresol 3; ACS-Cobra-Group (Torre de Miguel, Spain)	parabolic troughs + 7.5h storage	50	2012	€ 300 million
Thermosolar Borges (Borges Blaques, Spain)	parabolic troughs + biogas	22.5	2012	€ 150 million
Solaben2 (Logrosan, Spain)	parabolic troughs	50	2013	> € 250 million
Termosol 1 (Navallvialr de Pela, Spain)	parabolic troughs + 9h storage	50	2013	n.a.
Termosol 2 (Navallvialr de Pela, Spain)	parabolic troughs + 9h storage	50	2013	n.a.
Shams 1 (Madinat Zayed, UAE)	parabolic trough	100	2013	$ 600 million
Abhijeet Solar Project Rajasthan (Jaisalmer)	parabolic trough	50	2013	n.a.
Total (May 2013)		**2,939.15**		

Table 2: List of projects currently under construction with projected operation until 2014 [5, 6, 7]

Name of Project	Technology	Capacity [MW_{el}]	Start of construction and/or operation	Investment Volume
Solaben 1 & 6 (Logrosan, Spain)	parabolic troughs	100	Construction 2011 Operation 2013	> € 500 million
Cáceres, (Galisteo y Valdeobispo, Spain)	parabolic troughs	50	Construction 2011 Operation 2013	n.a.
Kogan Creek (Kogan Creek, Australia)	Fresnel	44	Construction 2011 Operation 2013	n.a.
Godawari Solar Project (Naukh, India)	parabolic trough	50	Construction 2011 Operation 2013	n.a.
Dhursar Dhursar (Rajasthan, India)	Fresnel	100	Construction 2011 Operation 2013	n.a.
Diwakar Askandra (Rajasthan, India)	parabolic trough	100 + 4h storage	Construction 2011 Operation 2013	n.a.
Gujarat Solar One Kutch (Gujarat, India)	parabolic trough	25 + 9h storage	Construction 2011 Operation 2013	n.a.
KVK Solar Energy Project Askandra (Rajasthan, India)	parabolic trough	100 + 4h storage	Construction 2011 Operation 2013	n.a.
Megha Solar Project Anantapur (Andrah Pradesh, India)	parabolic trough	50	Construction 2011 Operation 2013	n.a.
Agua Prieta II (Agua Prieta, Mexico)	parabolic trough	14	Construction 2011 Operation 2013	n.a.
Solana Generation Station Gila Bend (AZ, USA)	parabolic troughs	280	Construction 2010 Operation 2013	n.a.
Ivanpah 1, 2 & 3, Ivanpah Solar, San Bernardino (CA, USA)	solar tower + gas-fired start-up boiler	370	Construction 2010 Operation 2013	n.a.
Genesis Solar Energy Project Blythe (CA, USA)	parabolic troughs	250	Construction 2010 Operation 2013	n.a.
Crescent Dunes Tonopah (NV, USA)	Power Tower	110	Construction 2010 Operation 2013	n.a.
Abengoa Mojave Project Harper Dry Lake (CA, USA)	parabolic troughs	250	Construction 2010 Operation 2014	n.a.
KaXu Solar One, Poffader (Northern Cape, South Africa)	parabolic troughs	100	Construction 2012 Operation 2014	n.a.
Khi Solar One, Upington (Northern Cape, South Africa)	Power Tower	50	Construction 2012 Operation 2014	n.a.
Total		**1,943**		

In December 2009 the World Bank's Clean Technology Fund (CTF) Trust Fund Committee endorsed a CTD resource envelope for projects and programmes in five countries in the Middle East and North Africa to implement STE [8]. The budget envelope proposes CTF co-financing of $ 750 million (€ 577 million[14]), which should mobilize an additional $ 4.85 billion (€ 3.73 billion) from other sources and help to install more than 1.1 GW of STE by 2020.

As a follow up to this initiative, the World Bank commissioned and published a report early 2011 about the Local Manufacturing Potential in the MENA region [9]. The report concludes: *MENA could become home to a new industry with great potential in a region with considerable solar energy resources. If the STE market increases rapidly in the next few years, the region could benefit from significant job and wealth creation, as well as from enough power supply to satisfy the growing demand, while the world's renewable energy sector would benefit from increased competition and lower costs in STE equipment manufacturing.*

Within just a few years, the STE industry has grown from negligible activity to close to 5 GW_e either commissioned or under construction. More than ten different companies are now active in building or preparing for commercial-scale plants, compared to perhaps only two or three who were in a position to develop and build a commercial-scale plant a few years ago. These companies range from large organizations with international construction and project management expertise who have acquired rights to specific technologies, to start-ups based on their own technology developed in house. In addition, major renewable energy independent power producers such as Acciona, and utilities such as Iberdrola and Florida Power & Light (FLP) are making plays through various mechanisms for a role in the market.

The supply chain is not limited by raw materials, because the majority of required materials are glass, steel/aluminum, and concrete. At present, evacuated tubes for trough plants can be produced at a sufficient rate to service several hundred MW/yr. However, expanded capacity can be introduced fairly readily through new factories with an 18-month lead time.

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Technical Annex:

Trough Systems

The sun's energy is concentrated by parabolically curved, trough-shaped reflectors onto a receiver pipe running along the focal plane of the curved surface. This energy heats oil or another medium flowing through the pipe and the heat energy is then used to generate electricity in a conventional steam generator.

Power Tower Systems

The sun's energy is concentrated by a field of hundreds or even thousands of mirrors called **heliostats** onto a receiver on top of a tower. This energy heats molten salt flowing through the receiver and the salt's heat energy is then used to generate electricity in a conventional steam generator. The molten salt retains heat efficiently, so it can be stored for hours or even days before being used to generate electricity.

Dish/Engine Systems

A dish/engine system is a stand-alone unit composed primarily of a collector, a receiver and an engine. The sun's energy is collected and concentrated by a dish-shaped surface onto a receiver that absorbs the energy and transfers it to the engine's working fluid. The engine converts the heat to mechanical power in a manner similar to conventional engines—that is, by compressing the working fluid when it is cold, heating the compressed working fluid, and then expanding it through a turbine or with a piston to produce work. The mechanical power is converted to electrical power by an electric generator or alternator.

Production data for the global cell production[15] in 2012 vary between 35 GW and 42 GW. The uncertainty in this data is due to the highly competitive market environment, as well as the fact that some companies report shipment figures, while others report sales and again others report production figures. During the first three quarters of 2012 the market outlook for the current year improved considerably and in Asia a strong 4th quarter improved the overall capacity increase.

The data presented, collected from stock market reports of listed companies, market reports and colleagues, were compared to various data sources and thus led to an estimate of 38.5 GW (Fig. 1), representing a moderate increase of 8% compared to 2011 and another moderate increase is expected for 2013.

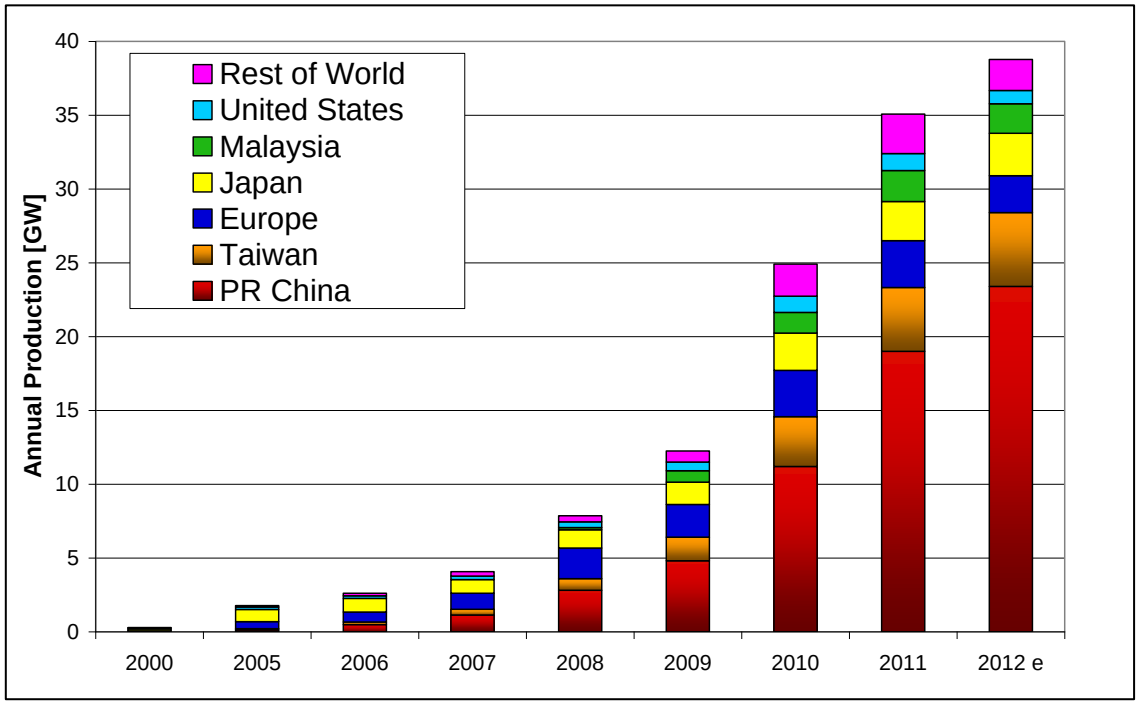

Figure 1: World PV Cell/Module Production from 2000 to 2012
(Data source: Photon Magazine [1], PV Activities in Japan [2], PV News [3] and own analysis)

Since 2000, total PV production increased by two orders of magnitude, with a compound annual growth rate (CAGR) of 50%. The most rapid growth in annual production over the last five years could be observed in Asia, where China and Taiwan together now account for more than 70% of world-wide production.

The change of the market from a supply restricted – to a demand-driven market and the resulting overcapacity for solar modules has resulted in a dramatic price reduction of PV systems of more

[15] **Solar cell production capacities** mean:
- In the case of wafer silicon based solar cells, only the cells
- In the case of thin-films, the complete integrated module
- Only those companies which actually produce the active circuit (solar cell) are counted
- Companies which purchase these circuits and make cells are not counted.

than 50% over the last four years. In the fourth quarter of 2012, the average system price for installed systems smaller 10 kWp was in the range of 1.75 €/Wp (2.27 $/Wp) in Germany and 2.10 €/Wp (2.75 $/Wp) in Italy, but between 4.6 and 6.2 $/Wp (3.5 – 4.8 €/Wp) in the USA and Japan [4, 5]. Early June 2013, further price reductions were reported by PVinsight with 1.97 $/Wp (1.54 €/Wp) for averaged world wide grid connected residential system prices and 1.47 $/Wp (1.13 €/Wp) for commercial systems [6]. In Germany engineering, Procurement and Construction (EPC) quotes for large systems as low as 0.8 €/Wp (1.04 $/Wp) have been reported for 2013, but they will yield almost no margin and will become impossible if import duties on Chinese modules are actually levied [7].

Market predictions for the 2013 PV market vary between 27.8 GW and 47 GW [7, 8] with a consensus value in the 35 GW range. For 2014 analysts expected a further increase to over 40 GW mainly driven by growing Asian markets. Even in the case of optimistic forecasts, massive overcapacities in cell and module manufacturing are still existing. Depending how the capacities are calculated they range between 60 to 70 GW in 2013. The consequence will be the continuation of consolidation in the PV industry with a continued price pressure in an oversupplied market, even if it might relax somewhat from the second half of 2013 on.

Despite the fact that a significant number of companies filed for insolvency, scaled back or even cancelled their expansion projects, the number of new entrants into the field, notably large semiconductor or energy related companies overcompensated this in the past. The announced production capacities – based on a survey of more than 300 companies worldwide – increased again in 2012 and will continue to do so in 2013 and 2014 but at a slower pace. However, the rapid changes in the sector and the difficult financing situation make a reasonable forecast for future capacity developments very speculative.

The existing overcapacity is a result of the very ambitious investments dating back to 2010. It was triggered by the more than 150% growth of the PV market that year, which peaked in equipment spending of about $ 14 billion (€ 10.8 billion) in 2011. Since then equipment spending has dramatically declined and will probably hit the bottom with around $ 1 to 2 billion (€ 0.77 to 1.54 billion) this year before a moderate recovery from 2014 onwards will be possible. This development had a serious effect on the equipment manufacturers all of which need a new strategy towards the PV industry now. Companies with no significant business segment outside the PV supply chain were hit most and some of them are struggling to survive the slump until the predicted recovery kicks in.

After the world-wide photovoltaic market more than doubled in 2010, the market grew again by almost 30% in 2011 and another 11% in 2012, despite difficult economic conditions. The 2010 market volume of 20.9 GW includes those systems in Italy, which were reported under the second "*conto energia*" and installed, but connected only in 2011. There is an uncertainty about the actual installation figures in China. The Chinese National Energy Administraion published a cumulative installed capacity of 7 GW at the end of 2012, whereas most other market reports cite figures between 8 and 8.5 GW [9]. The stronger than expected market in Germany and the strong increase of installations in Asia and the USA resulted in a new installed capacity of about 30 GW in 2012 and for 2013, an increase to about 35 GW is expected (Fig. 2). This represents mostly the grid connected photovoltaic market. To what extent the off-grid and consumer product markets are included is not clear, but it is believed that a substantial part of these markets are not accounted for as it is very difficult to track them.

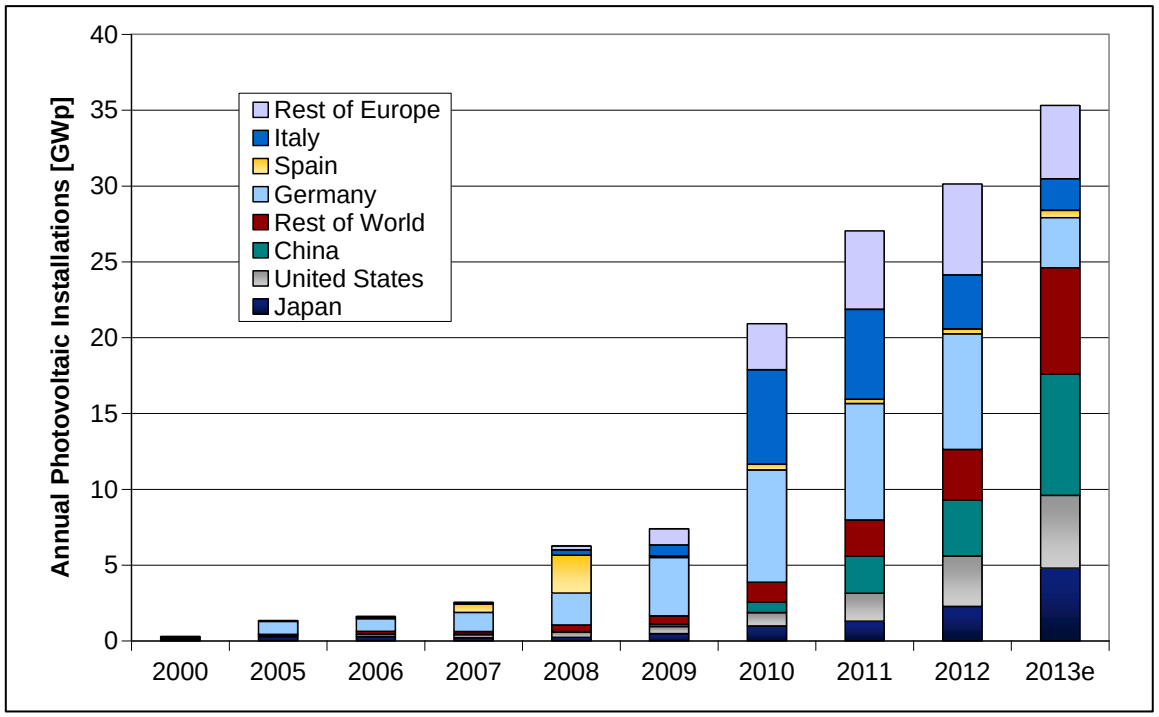

Figure 2: Annual photovoltaic installations from 2000 to 2013
(Data source: [8, 9, 10] and own analysis)

With a cumulative installed capacity of over 69 GW, the European Union is leading in PV installations of the total worldwide 100 GW of solar photovoltaic electricity generation capacity at the end of 2012.

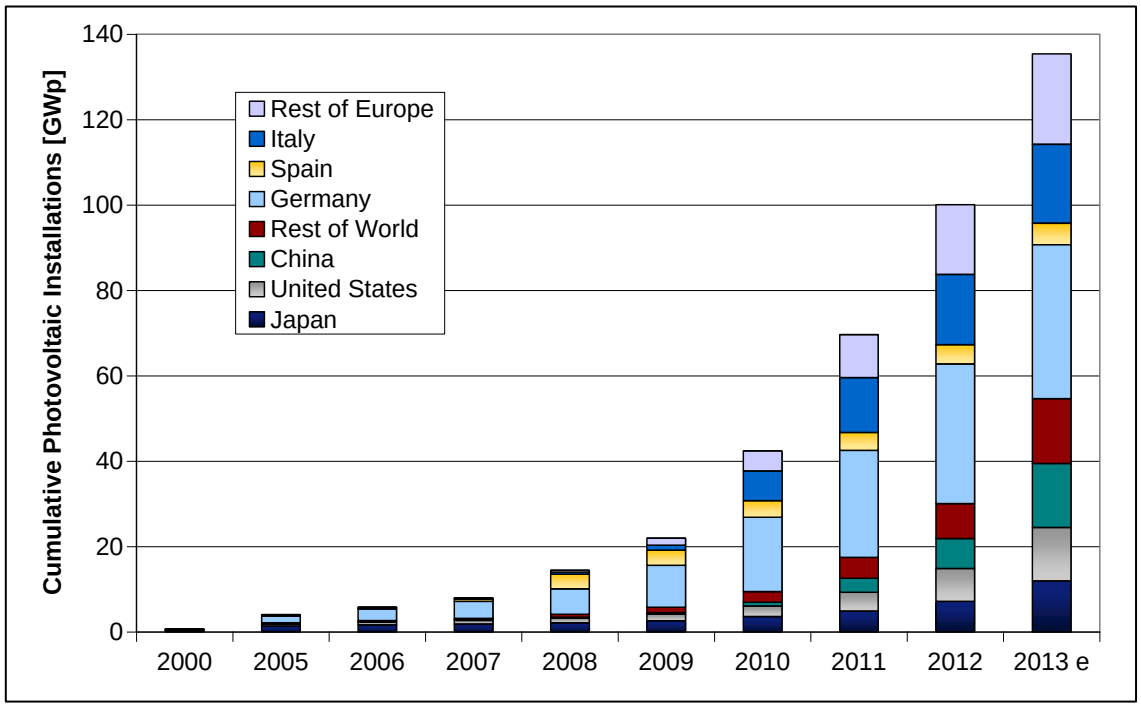

Figure 3 Cumulative Photovoltaic Installations from 2000 to 2013
(data source: [8, 9, 10] and own analysis)

The **Asia & Pacific Region** shows an increasing trend in photovoltaic electricity system installations. There are a number of reasons for this development, ranging from declining system

prices, heightened awareness, favourable policies and the sustained use of solar power for rural electrification projects. Countries such as Australia, China, India, Indonesia, Japan, Malaysia, South Korea, Taiwan, Thailand, The Philippines and Vietnam show a very positive upward trend, thanks to increasing governmental commitment towards the promotion of solar energy and the creation of sustainable cities.

The introduction or expansion of feed-in-tariffs is expected to be an additional big stimulant for on-grid solar PV system installations for both distributed and centralised solar power plants in countries such as Australia, Japan, Malaysia, Thailand, Taiwan and South Korea.

In 2012 about 8.5 GW of new PV electricity generation systems were installed in the region, which corresponds to a 60% growth compared to 2011. The largest market was China with 3.7 GW followed by Japan with 2.3 GW MW and Australia with over 1 GW. For 2013 a market increase to about 15 GW is expected, driven by the major market growth in China (~ 6 to 8 GW), India (> 1 GW), Japan (> 4 GW), Malaysia and Thailand. For 2014 the market expectations even exceed 20 GW.

European Union: Market conditions for photovoltaics differ substantially from country to country. This is due to different energy policies and public support programmes for renewable energies and especially photovoltaics, as well as the varying grades of liberalisation of domestic electricity markets. After a tenfold increase of solar photovoltaic electricity generation capacity between 2001 and 2008, the newly installed capacity increased more than six fold in the last four years to exceed 69 GW cumulative installed capacities at the end of 2012.

The legal framework for the overall increase of renewable energy sources was set with the Directive 2009/28/EC, and in their National Renewable Energy Action Plans (NREAPs), 26 Member States have set specific photovoltaic solar energy targets, adding up to 84.5 GW in 2020. However, since the submission of the NREAPs in 2010 a number of positive signs have emerged for PV. In Italy, the cumulative installed capacity by October 2012 has already reached 16 GW or double the NREAP target. In August 2011 Greece announced the "Helios" project, which aims to install up to 10 GW of PV electricity systems on public land by 2020.These developments indicate that the targets set in the NREAPs should be seen as the guaranteed minimum and not the overall goal.

In 2011 Italy overtook Germany as the biggest market with a new connected capacity of 9.2 GW versus 7.5 GW respectively. In 2012 the main European markets were Germany (7.6 GW), Italy (3.5 GW), France (1 GW), Greece (> 0.9 GW) and the United Kingdom with almost 0.9 GW.

North America: In 2012, Canada increased its cumulative installed PV capacity by more than 50% to about 0.9 GW. For 2013 a further increase of the market to 400 to 500 MW is estimated. This development is mainly driven by the introduction of a feed-in tariff in the Province of Ontario in 2009 as well as decreasing PV system prices.

With over 3.3 GW of new installed PV capacity, the USA reached a cumulative PV capacity of 7.5 GW at the end of 2012. Utility PV installations again more than doubled, compared to 2011 and became the largest segment with 1.7 GW in 2012. The top ten States - California, Arizona, New Jersey, Nevada, North Carolina, Hawaii, Maryland, Texas and New York, accounted for more than 88% of the US PV market [11]. For 2013 an increase of the US market between 3.5 and 4.5 GW is estimated.

PV projects with Power Purchase Agreements (PPAs), with a total capacity of 10.5 GW, are already under contract and over 3 GW of these projects are already financed and under

construction [11]. If one adds those projects in an earlier development stage, the pipeline stands at almost 22 GW.

Many State and Federal policies and programmes exist and one of the most comprehensive databases about the different support schemes in the US is maintained by the Solar Centre of the State University of North Carolina. The Database of State Incentives for Renewable Energy (DSIRE) is a comprehensive source of information on State, local, utility, and selected Federal incentives that promote renewable energy. All the different support schemes are described therein and it is highly recommended to visit the DSIRE web-site http://www.dsireusa.org/ and the corresponding interactive tables and maps for details.

The 2013 market expectations for Canada and the USA together vary between 4 and 5 GW.

The Photovoltaic Industry has changed dramatically over the last few years. China has become the major manufacturing place followed by Taiwan and Japan.

Looking at Photovoltaics it is important to remember, that the PV industry is more than just cell and module manufacturing and to grasp the whole picture one has to look at the whole PV value chain. Besides the information in this paper about the manufacturing of solar cells, the whole upstream industry (e.g. materials, polysilicon production, equipment manufacturing), as well as the downstream industry (e.g. inverters, BOS components, system development, installations) has to be looked at as well.

In June 2013, the worldwide average price of a residential system without tax was given as 1.97 USD/Wp (1.54 EUR/Wp) [6]. Taking this price and adding a surcharge of 0.16 EUR/Wp for fees, permitting, insurance, etc., an installed PV system costs 1 700 EUR/kWp without financing and VAT. The breakdown of costs is depicted in Fig. 4.

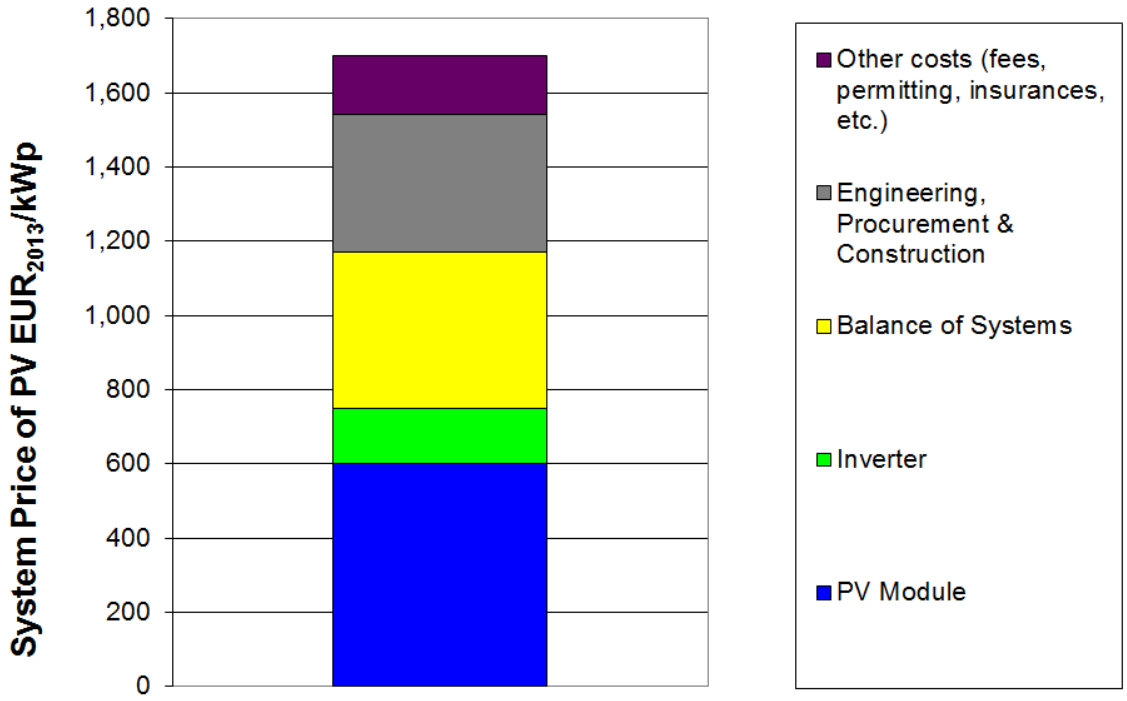

Figure. 4: Price breakdown of residential PV system (June 2013)

As shown in Tables 1, already at 5% Return on Investment (ROI) the financing costs are the largest single cost factor. Together with fees and permitting costs, they comprise one-third of the electricity generation costs from a residential PV system for the first 20 years (Figs. 5).

Depending on the actual radiation level, the 1.5% operation, maintenance and repair (O&M) costs are the second or third largest cost factor. The O&M costs cover the foreseeable repairs and exchange costs of components like the inverter, as well as the annual degradation of the solar modules as specified by the manufacturers. Adding a conservative safety margin of 1.5 EUR cent/kWh on top of the 2.5 EUR cent /kWh results in an electricity price of 4.0 EUR cent/kWh after the 20-year financial payback period.

Table 1: LCOE of PV-generated electricity for residential systems with a system price of 1 700 EUR/kWp (excluding VAT, because the differences in the various countries are too large), 1.5% O&M cost, an annual generation of 1 000 kWh/kWp/year and a financial lifetime of 20 years.

	Price	LCOE Product	LCOE Capital			LCOE O&M 1.5%	LCOE Total		
	[EUR/kWp]	[EURcents/kWh]							
Return on Investment		0%	3%	5%	10%		3%	5%	10%
PV Module	600	3.0	0.9	1.6	3.4	0.9	4.8	5.5	7.3
Inverter	150	0.75	0.25	0.35	0.85	0.2	1.2	1.3	1.8
Balance of Systems	420	2.1	0.6	1.1	2.4	0.6	3.3	3.8	5.1
Engineering Procurement & Construction	370	1.85	0.55	0.95	2.15	0.6	3.0	3.4	4.6
Other costs (fees, permitting, insurance, etc.)	160	0.8	0.2	0.4	0.9	0.2	1.2	1.4	1.9
Total	1 700	8.5	2.5	4.4	9.7	2.5	13.5	15.4	20.7

According to investment analysts and industry prognoses, solar energy will continue to grow at high rates in the coming years. The different PV industry associations, as well as Greenpeace, the European Renewable Energy Council (EREC) and the International Energy Agency, have developed new scenarios for the future growth of PV systems. Table 6 shows the different scenarios of the Greenpeace/EREC study, the IEA PV Technology Roadmap and the different 2011 and 2012 IEA World Energy Outlook scenarios [13, 14, 15, 16]. It is interesting to note that the 2015 capacity values of the Greenpeace reference scenario and the IEA 2011 scenarios (in red) were already exceeded in 2012. With forecasted new installations of between 129 and

150 GW in 2013, 2014 and 2015, even the Greenpeace revolution scenario no longer seems like fiction [17].

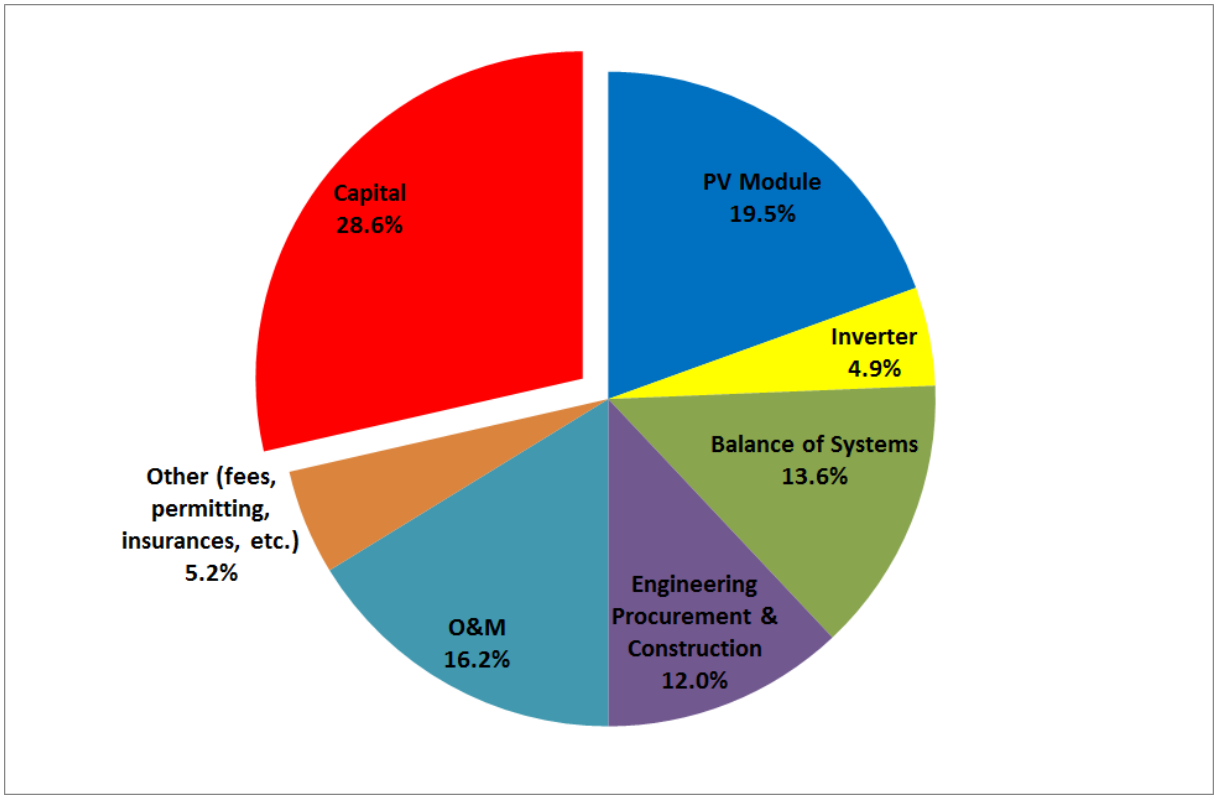

Figure 10: LCOE cost shares for 5% ROI

Table 2: Evolution of the cumulative solar electrical capacities until 2050 [13, 14, 15, 16]

Year	2012 [GW]	2015 [GW]	2020 [GW]	2030 [GW]	2035 [GW]
Actual Installations	**100**				
Greenpeace[1] (reference scenario)		88	124	234	290
Greenpeace[1] ([r]evolution scenario)		234	674	1 764	2 420
IEA PV Technology Roadmap[2]		76	210	872	1,330
IEA New Policy Scenario 2011[3]		112	184	385	499
IEA New Policy Scenario 2012		153	266	491	602
IEA 450 ppm Scenario 2011[3]		70	220	625	901
IEA 450 ppm Scenario 2012[4]		150	303	720	966

1: 2035 values are extrapolated, as only 2030 and 2040 values are given

2: 2015 and 2035 values are extrapolated, as only 2010, 2020, 2030 and 2040 values are given

3: 2015 values are extrapolated, as only 2009 and 2020 values are given

4: 2015 value is extrapolated, as only the average growth rate from 2010 to 2035 and the 2020 value is given

These projections show that there are huge opportunities for photovoltaics in the future if the right policy measures are taken, but we have to bear in mind that such a development will not happen by itself. It will require the sustained effort and support of all stakeholders to implement the envisaged change to a sustainable energy supply with photovoltaics delivering a major part. The main barriers to such developments are perception, regulatory frameworks and the limitations of the existing electricity transmission and distribution structures.

With worldwide 100 GW cumulative installed photovoltaic electricity generation capacity installed by the end of 2012, photovoltaics still is a small contributor to the electricity supply, but its importance for our future energy mix is finally acknowledged.

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2013 SNAPSHOT ON EUROPEAN WIND ENERGY

The state of play

Some 44.8 GW [1, 2] of new wind turbine capacity was installed in 2012, bringing the worldwide total installed wind capacity to around 283 GW (Figure 1). This capacity can produce about 650 TWh (assuming an average capacity factor of 2200 hours or 25 %.) of electricity in an average year, or approximately 3 % of global electricity demand [3].

With 13 GW of new installations and a market share of 28% each, China and the US led the wind market in 2012, followed by Germany and India with around 2.4 GW each (5.5 %). European Union Member States added in total 11 896 MW (26 %), with Germany followed by the UK (1 897 MW), Italy (1 273 MW) and Spain (1 122 MW) as main contributors. Another four EU countries added 500 MW or more: Romania (923 MW), Poland (880 MW), Sweden (846 MW), and France (757 MW). Other European countries and Turkey added 2 665 MW. Of the rest of the world, Brazil with 1 077 MW, Canada (935 MW) and Mexico (801 MW) also surpassed the 500-MW mark.

The total value of new generation capacity installed in 2012 is estimated at €54 billion, giving an average capital cost of around €1 250/kW.

China maintained a 15-GW lead over the United States in terms of installed capacity (75.3 vs. 60 GW), although an estimated 15 GW of non-grid-connected wind turbines in China puts both countries on a par in terms of operational capacity. They were followed by Germany (31.3 GW), Spain (22.8 GW) and India (18.4 GW).

A stronger European market led it to increase its share to 28% of global installations, after last years' 25 % share, a small recovery from the continuous drop in market share since 75 % in 2004.

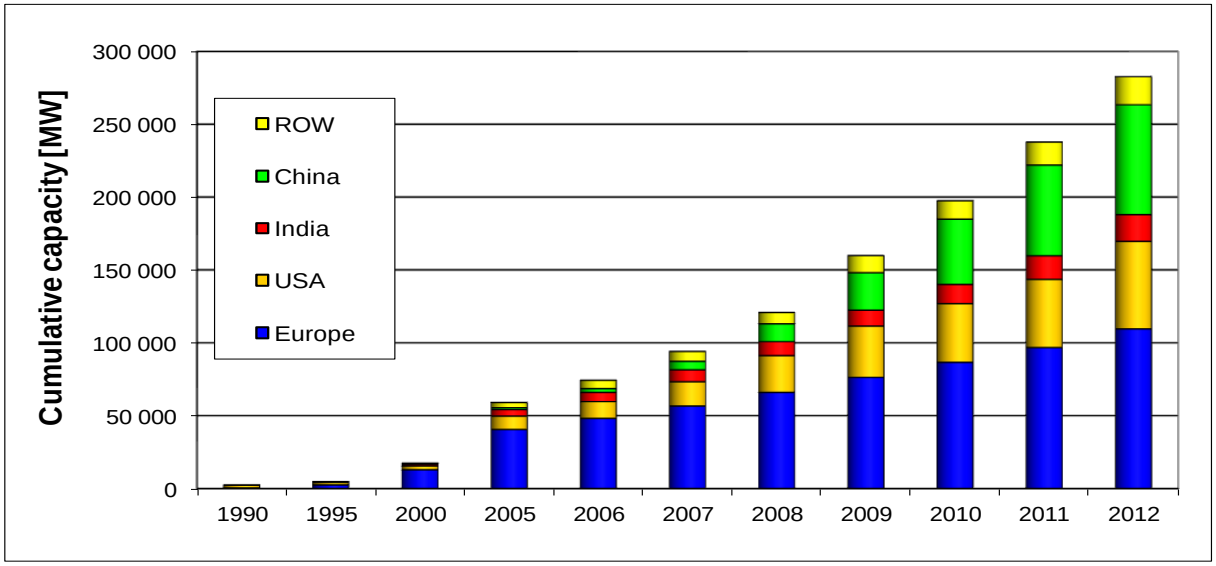

Figure 1: Cumulative worldwide installed wind power capacity from 1990 to 2012. Data Source: GWEC's Annual market update 2012 [1] and similar reports of previous years.

In terms of percentage annual growth, in 2012, the European Union's wind capacity grew by 12.7 %, below the global average of 18.8 %. The total EU capacity of 106 GW is equal to 11.4 % of the total European electricity generation capacity [4] and is capable of producing an average of 203 TWh[16] of electricity or roughly 7.3 % of European final electricity consumption.

Figure 2 shows the breakdown of the European market per country in 2012. In terms of year-on-year growth and among the largest markets, Poland (+102 %), Romania (+77 %), the United Kingdom (+46 %) and Italy (+34 %) presented the highest growth. Of the other large markets Sweden (+11 %) and Spain (+7 %) presented year-on-year growth, whereas the French market contracted (-9 %).

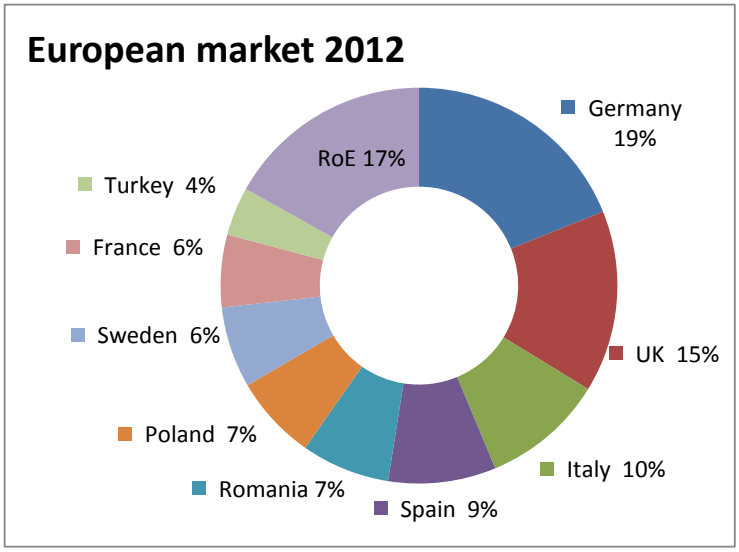

Figure 2: European wind market share 2012. Source: EWEA [**4**]

Figures for offshore wind installations vary widely depending on the source, due to the different methodologies used. Based on turbine (and not whole wind farm) commissioning date, 2012 was a good year with a 67 % increase in installed capacity from 825 to 1 380 MW. The latter figure includes partial commissioning of Anhold, BARD Offshore I, Lincs, and London Array wind farms which are being finished in 2013.

Country	<2003	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Belgium							30		165		185	380
Denmark	210	210						230	207		50	908
Finland	1						18		2			21
Germany							5	60	40	88	80	273
Ireland			25									25
Netherlands	19				108		120					247
Norway								2				2
Portugal										2		2
Sweden	23					110		30			4	168
UK	4	60	60	90	90	100		382	556	667	940	2948
World total	257	270	86	90	198	212	173	775	1240	825	1381	5508

Table 1: Annual installations offshore, in MW, rounded to the nearest integer. Totals are world totals and thus include countries not detailed in the table. Source: JRC.

The turbine manufacturers market share (Figure 3) revealed by the different sources [2, 5] show a tie at the lead and suggests that the long-term leader Vestas (DK) was unseated by GE Wind of the US. This would be the natural consequence of GE being the market leader in a market, the US, which saw record installations after growing 93 % year-on-year. Three European companies

[16] Assuming a capacity factor of 21.9% or 1918 hours, equal to the 10-year European average to 2011. Source: JRC based on Eurostat and industry data.

follow (Siemens, Enercon and Gamesa), then Suzlon of India (a third of whose installations belong to its European subsidiary REpower), then four manufacturers from China: Goldwind, Guodian United Power, Sinovel and Ming Yang.

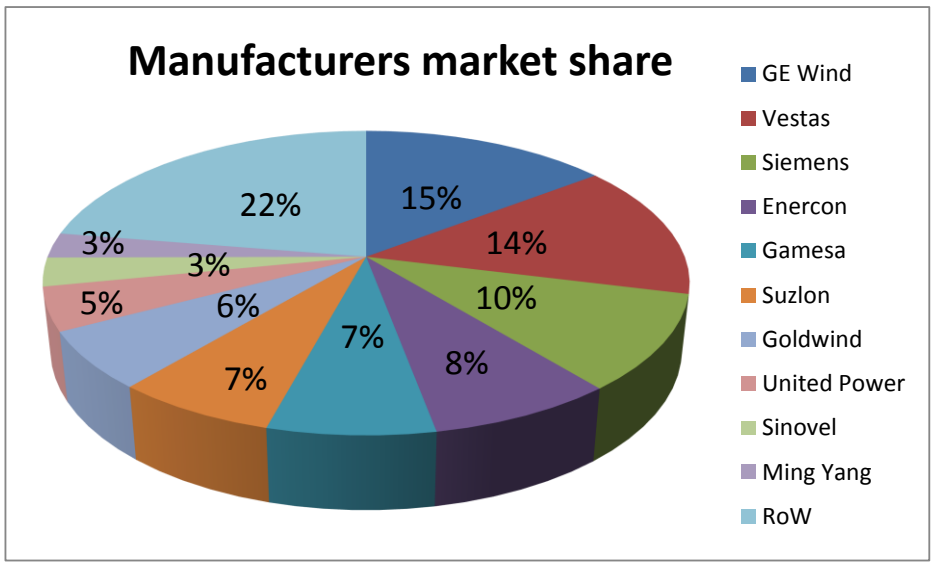

Figure 3: Manufacturer market share 2012 over 43.14 GW of installations. Elaborated with data from [2] and [5]. Suzlon data includes its subsidiary REpower (Germany)

Based on [2] the five largest firms together covered 54.6 % of the market, showing higher market concentration than in 2011 (47.2 %). However, the share of the top-ten suppliers remained stable at 77.3 % of the market versus 78.5 % in 2011. European manufacturers[17] increased their market share from 37.3 % in 2011 to 42.8 % in 2012, partly as a result of significantly lower installations in China –which resulted in lower share for Chinese manufacturers.

Projections and analysis

Table 2 shows that global annual market projections expect a reduction of installations in 2013 and a rebound in subsequent years.

Source	2013	2014	2015	2016	2017
BTM [2]	40.4	47.6	45.1	50.9	57.7
GWEC [1]	39.6	45.3	51.0	56.2	61.2
BNEF [9]	38.6	45.8	44.9	48.4	-
MAKE Consulting [10]	45.0	52.5	52.5	52.5	
JRC projections	43.8	47.5	50.0	54.0	57.0

Table 2: Annual market projections for different consulting and sector companies, in GW

Factors that influence current projections include an expected increase of the annual Chinese market to between 16 and 20 GW, and an increase in India, Brazil, South Africa and other emerging markets as well as offshore.

Based on developments in European emerging countries and the offshore market, the European market could increase annual installations to around 10-12 GW despite a reduction in installations expected in current leading markets. The most worrying situation was produced in Spain, where a government decision stopped all support to new renewable installations, and resulting in the complete halt of the wind market.

[17] Including REpower (the European subsidiary of Suzlon), which according to [2] installed 2 122 MW out of the 3 177 MW installed by the Suzlon group.

In North America, the US market and thanks to the extension to their main support mechanism, the Production Tax Credit (PTC), will likely reach levels just short of the 2012 records. Canada and Mexico keep showing signs of increased growth and very positive projections, in some cases aided by know-how (e.g. developers' know-how) from the US market.

The evolution of the annual manufacturer ranking shows that there are one or two truly global suppliers, Vestas and perhaps Gamesa, in the sense of having balanced presence in the different markets. Chinese manufacturers descended from positions 2, 6, 7 and 10 to positions 7 to 10 because of their dependence on a Chinese market which shrunk by 27 % in 2012, and their limited expansion beyond China. The US firm GE Wind climbed to number one because of its exposure to its home market, where it held 38.5 % share in 2012 (5 014 MW [6]), and the large growth of this market. Had not it been for its home market GE would be a minor market actor with 1 682 MW installed outside the US.

Siemens claimed to third place thanks to its exposure to the US and offshore markets with 2 638 [6] and 988 MW [8] respectively out of a total 4 114 MW [2]. But perhaps the most significant performance is that of Enercon which, at 3 538 MW, ranks fourth in 2012 installations despite not being present in markets covering 64.5 % of the market (US, China, India and offshore). Still, Enercon was aided by a high exposure to its home market (57 %, [2])

Chinese firms' dominance of their national market increase slightly from 91 % in 2011 to 92 % in 2012, but sold only 3.5 % of their turbines abroad, 431 MW [8]. This figure is significantly more than the 1.2 % of the total 17 600 MW of 2011 and shows a continuous grow in Chinese exports, from 213 to 431 MW[18]. Four foreign firms (Vestas, Gamesa, GE and Siemens) installed 1018 MW in China in 2012, 7.8 % of the Chinese market, but a significant reduction over the 1 626 MW installed in 2011 and the 2 000 MW installed in 2010.

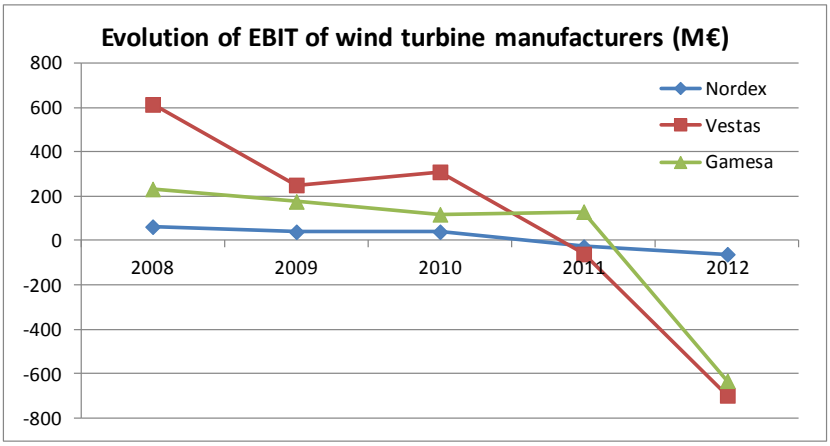

Figure 4: Evolution of the EBIT of wind turbine manufacturers, 2008 - 2012, for selected European companies. Source: company annual reports.

Turbine manufacturers are under very high pressure and not financially healthy. Figure 4 shows a sample of the business evolution of selected European wind turbine manufacturers as reflected in their annual EBIT (earnings before interest and tax). 2012 figures for Vestas and Gamesa include restructuring costs (one-off items such as write-downs of assets). Production overcapacity and fierce competition are two of the causes of these problems, but the sector is damaged by inconsistent support policies e.g. changing remuneration with retroactive effect – that affect investor confidence in some specific markets, with the danger of propagating the "me too" effect to healthy ones.

[18] Methodologies on Chinese exports might not be comparable to installed data. In effect, at least until 2011 annual wind turbine data reported by CWEA was installed capacity for Chinese installation but exports reflected turbines sent abroad and not necessarily installed nor commissioned in the same year of export.

The companies included in Figure 4 are not the only ones suffering in the wind sector. Some companies went bankruptcy or filed for insolvency, e.g. turbine manufacturer Fuhrländer of Germany, and offshore foundations manufacturers Smulders (Netherlands) and SIAG Nordseewerke (Germany). Other companies declared reduction in profits.

In this context, it is interesting to note some of the different strategies that manufacturers have defined for survival. One of them is downsizing, also seeing as the reduction of working capital through outsourcing, e.g. Vestas and Gamesa, through strengthening design collaboration with key component suppliers and using standard components more often. This opens a door for non-European suppliers to raise its share of the turbine value added, e.g. Siemens "has localised the purchase of wind turbine hulls, principal axis and gearboxes in China" since 2008.

Company annual reports show two other trends. Manufacturers claim that cost reductions are possible: Nordex expects to reduce turbine product costs "by 4% in 2013 and by 15% by 2015 relative to 2012"; Vestas has implemented "more than 100 product cost-out initiatives"; Gamesa "has launched new manufacturing processes with the goal of optimising costs" and claims positive results. This is very interesting: if these companies can reduce costs to that extent, then others probably can do it too, thus forming the basis for future reductions in the cost of turbines and therefore in the cost of energy.

A second trend is the increasingly aggressive policies towards capturing the operation and maintenance (O&M) market. Most turbine manufacturers are proud to show an increase in income share from this service and the reason is that O&M guarantees income for several years. As a consequence –possibly backed by lower O&M needs of newer, more reliable turbines, the O&M market is becoming more competitive, and prices offered to developers go down even below 10€/MWh (in variable terms).

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RES STATUS SNAPSHOT

Total RES share

Total RES share in EU 27 in gross final energy consumption has followed an increasing trend starting from 8.1% in 2005 reaching 13% in 2011[19]. Such a trend is planned to continue in EU 27 had up to 2020 reaching a share of 20.6% in gross final energy consumption (Figure 1).

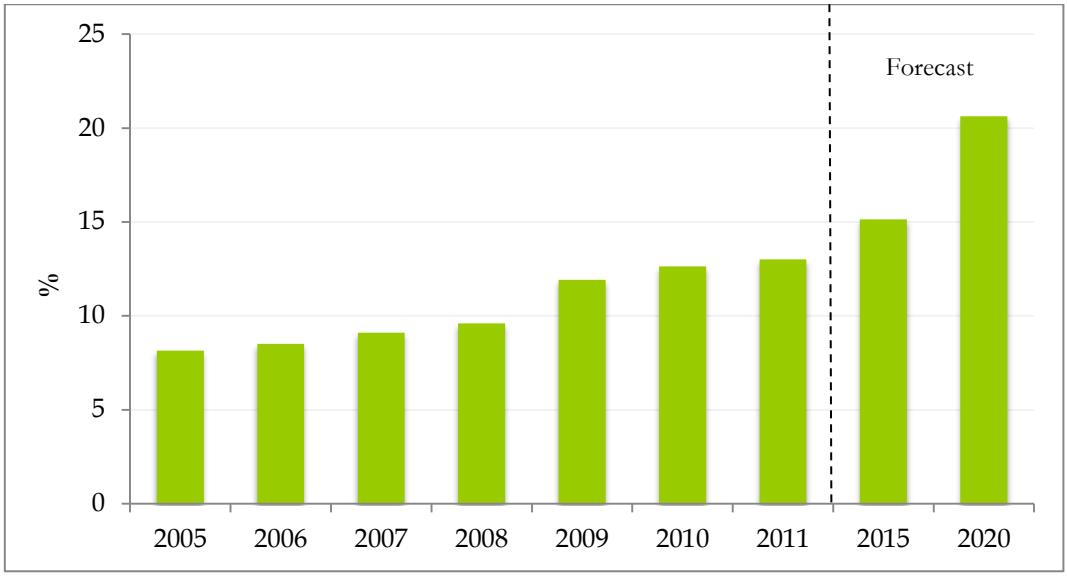

Figure 1. Total RES share in EU 27, 2005-2020

In 2009 almost 12% of gross final energy consumption in EU 27 was originated by renewable energy sources and in 2010 this share reached 12.6%.

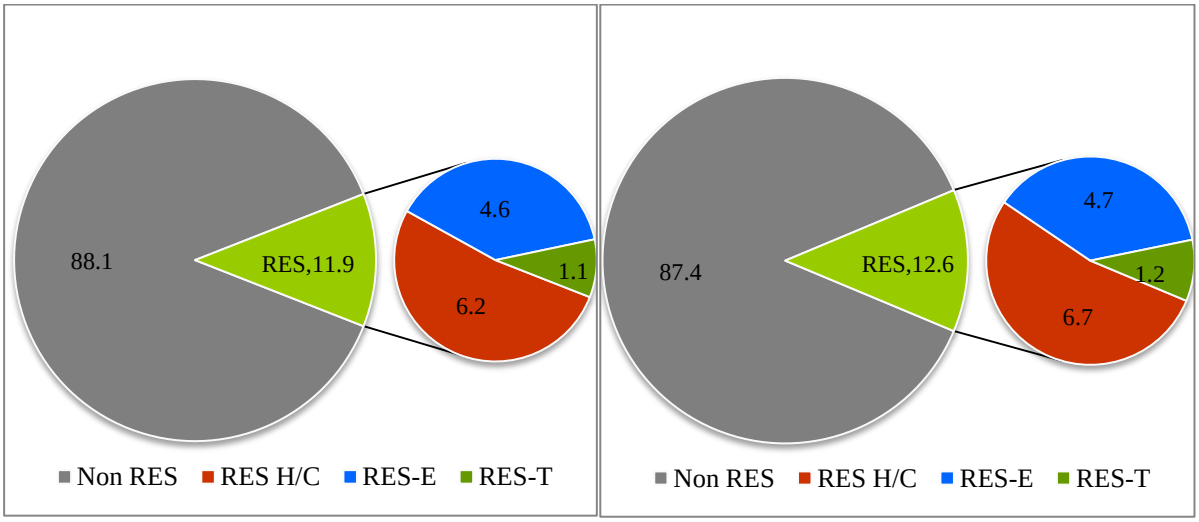

Figure 2. Contribution of overall RES, RES-H&C, RES-E and RES-T in GFEC in EU 27, 2009 (left) – 2010 (right)

RES consumption in the heating and cooling sector represented the highest sectorial contribution in total RES consumption in gross final energy in EU 27 with 6.2% (2009) and 6.7%

[19] Source : Eurostat table code t2020_31 (total RES share in GFEC for years 2006, 2007, 2008 and 2011)

(2010) followed by RES consumption in electricity sector (4.6% and 4.7%) and RES consumption in transport sector (1.1% and 1.2%) (Figure 2).

Sweden reported for period 2010-2011 the highest share of renewable energy sources in gross final energy consumption with respectively 47.8% and 46.8%, followed by Latvia (32.5% and 33.1%), Finland (33.1% and 31.8%) and Austria (30.8% and 30.9%). The lowest RES shares in gross final energy consumption were reported by Malta with 0.9% and 0.4%, Luxemburg (3% and 2.9%) and United Kingdom (3.3% and 3.8%) (Table 1).

Table 1[20]. Total RES share in GFEC in EU 27, 2005-2020

	2005	2009	2010	2011[21]	2020 target
BE	2.2	4.5	5.1	4.1	13.0
BG	9.6	11.0	12.6	13.8	16.0
CZ	6.1	n.a	8.8	9.4	14.0
DK	17.0	19.9	21.8	23.1	30.4
DE	6.5	10.2	11.3	12.3	19.6
EE	16.6	22.7	24.0	25.9	25.0
IE	3.1	5.0	5.5	6.7	16.0
EL	7.0	8.4	9.7	11.6	18.0
ES	8.2	12.5	13.5	15.1	20.8
FR	9.6	12.4	12.8	11.5	23.0
IT	4.9	8.9	10.1	11.5	17.0
CY	2.9	4.8	5.2	5.4	13.0
LV	32.6	34.3	32.5	33.1	40.0
LT	15.0	20.0	19.7	20.3	24.0
LU	0.9	2.9	3.0	2.9	11.0
HU	4.2	8.2	8.8	8.1	14.7
MT	0.0	0.9	0.9	0.4	10.2
NL	2.5	4.1	3.7	4.3	14.5
AT	23.3	30.9	30.8	30.9	34.2
PL	0.0	8.9	9.5	10.4	15.9
PT	19.8	24.6	24.6	24.9	31.0
RO	17.9	21.8	22.4	21.4	24.0
SI	16.2	19.0	19.9	18.8	25.3
SK	6.7	10.3	10.2	9.7	14.0
FI	28.8	32.0	33.1	31.8	38.0
SE	39.7	47.3	47.8	46.8	50.2
UK	1.4	3.0	3.3	3.8	15.0
EU 27	**8.1**	**11.9**	**12.6**	**13.0**	**20.6**

Total RES installed capacity

RES installed capacity in EU 27 increased from 167.7 GW in 2005 to 241.1 GW in 2010 with an annual growth rate of +8.8%. Total RES installed capacity in EU 27 is projected to double in 2020 reaching 476 GW.

[20] Source: NREAPs and EU 27 Renewable Energy Progress Reports. No data available for CZ in 2009
[21] Source: Eurostat table t2020_31

Hydropower sector provided the highest contribution in renewable energy installed capacity in EU 27 with 46.4% in 2009 and 41.7% in 2010. The additional hydropower capacity installed in year 2011[22] was estimated to 1.2 GW with a growth rate of 1.2%. Wind power provided in 2010 a contribution equal to 35.3% of total RES installed capacity and in 2020 is planned to reach the 210.6 GW sectorial target having a 2.5 times increase from year 2010. Solar contribution in total RES installed capacity reached 29.6 GW in 2010 and it will have the highest increase among renewables (3 times) in 2020 reaching 90.4 GW. Solar technology had the highest relative increase from 2009 with 77.6%. Biomass contribution to RES installed capacity was almost constant around 11% in both 2009 and 2010 years with a 9.3% increase in 2010 (Figure 3).

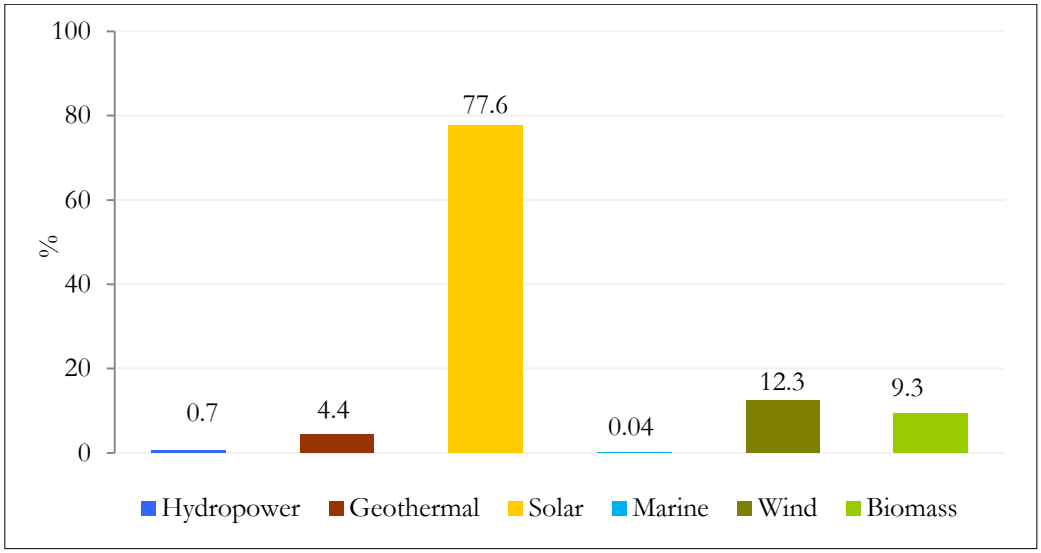

Figure 3. Relative increase renewable electricity technologies in RES installed capacity, 2010

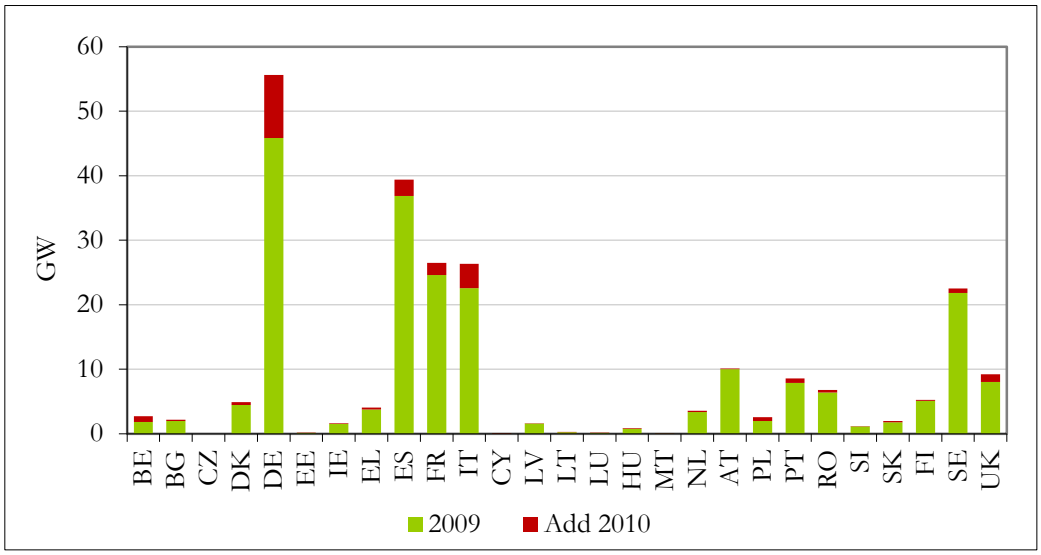

Figure 4. Total RES installed capacity in EU 27 MS, 2009-2010

Leading countries in total RES installed capacity in 2009 and 2010 were Germany with respectively 45.9 GW and 55.6 GW followed by Spain with 36.9 GW and 39.4 GW, France with 24.6 GW and 26.5 GW, Italy with 22.6 GW and 26.3 GW and Sweden with 21.8 GW and 22.5 GW (Figure 3). Contribution of these countries in total RES installed capacity accounted in both years for almost 71%.

[22] Source: Eurostat table nrg_113a

Total RES contribution

Total RES contribution in GFEC in EU 27 increased from 4144.3 PJ (99 Mtoe) in 2005 to 6246.1 PJ (149.2 Mtoe) in 2010 with an average annual growth rate of +10.1 % (2101.8 PJ or 50.2 Mtoe). In 2020 EU 27 has planned to contribute with 10194.2 PJ (243.5 Mtoe) from renewables with an expected increase from 2010 equal to 3948.1 PJ (94.3 Mtoe). In 2011 total renewable energy contribution in EU 27 was estimated to 6796.3 PJ (162.3 Mtoe) with an annual increase from 2010 equal to 550 PJ (13.1 Mtoe) and a growth rate of +8.8% (Figure 5).

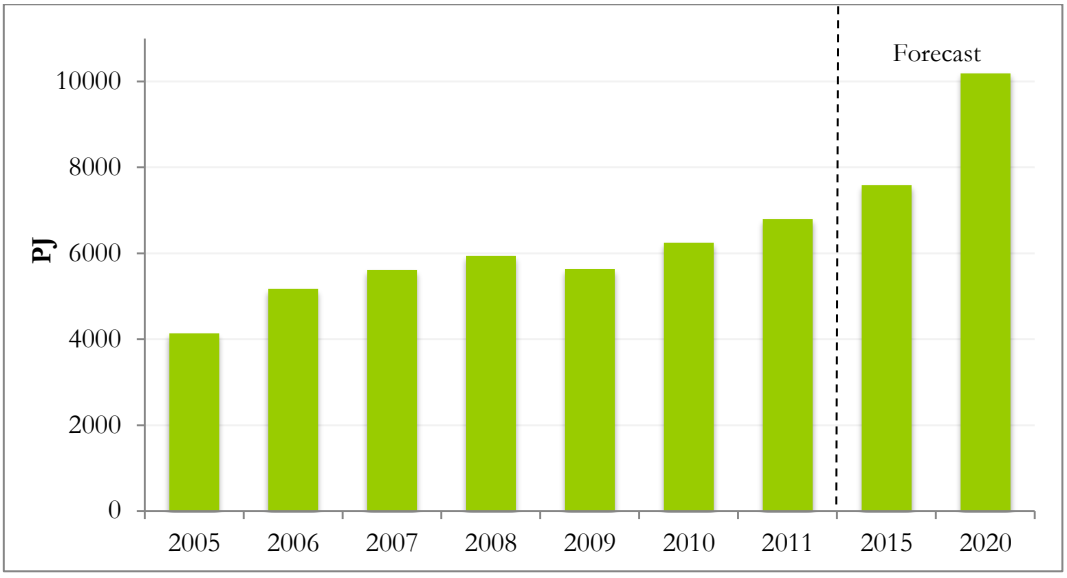

Figure 5[23]. Total RES development in EU 27, 2005-2020

The sector showing the highest fraction of consumption originated by RES is the electricity sector with 19.1% in 2009 and 19.7% in 2010. RES fraction in heating and cooling and transport sectors increased respectively from 13.7% and 4.2% in 2009 to 14.4% and 4.8% in 2010 (Fig. 6).

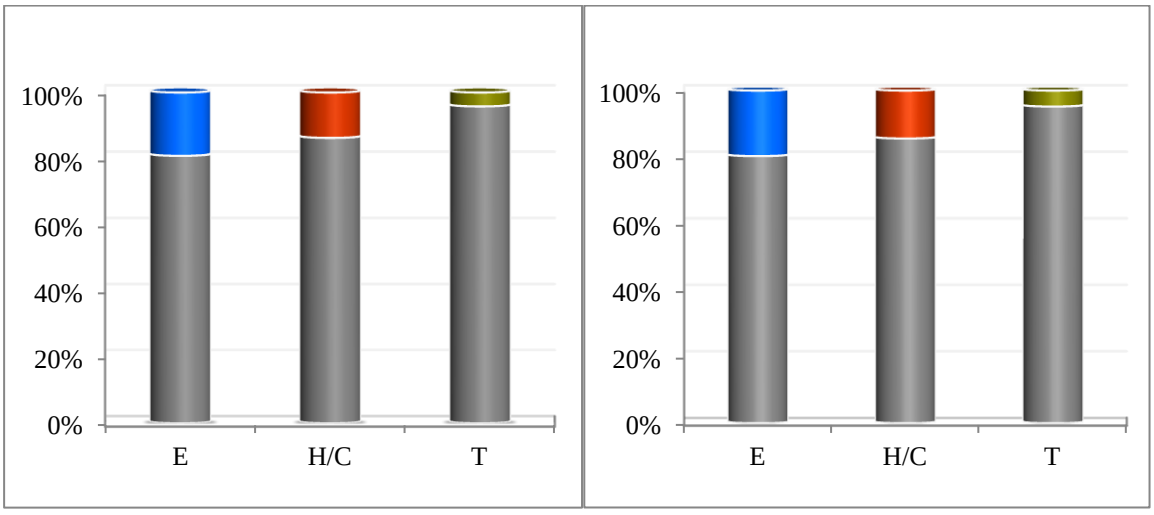

Figure 6. Energy fraction originating by RES in each consumption sector in EU 27, 2009 (left) – 2010 (right)

Nevertheless, in absolute terms the main contribution in total RES, 54%, was achieved in heating and cooling sector with 3379.8 PJ (80.7 Mtoe) RES electricity contribution in this year reached

[23] Source: Eurostat table ten00081 (total RES development for years 2006, 2007, 2008 and 2011)

37% with 2310.5 PJ (55.2 Mtoe). RES in transport sector with single counting reached in 2010 555.8 PJ (13.3 Mtoe) with a 9% contribution to total RES.

Renewable technologies role analysis in total RES contribution reveals that biomass remain the main contributor in 2010 with 56.9% (3557.4 PJ). Hydropower followed with 1201.4 PJ (333.7 TWh) with 19.2% with only 1.4% increase from 2009. Wind contribution reached in 2010 almost 9% with 558.5 PJ (155 TWh) having the second highest relative increase from 2009 with 13.6%. Solar technology provided in 2010 a 2.3% contribution with 146.2 PJ (40.6 TWh) showing the highest relative increase with 38.2%. Relative increases in 2010 of biomass and biofuels compared with 2009 amounted respectively 13.2% and 12.4%. Only geothermal technology presented a decrease in 2010 with 4.4% (Figure 7).

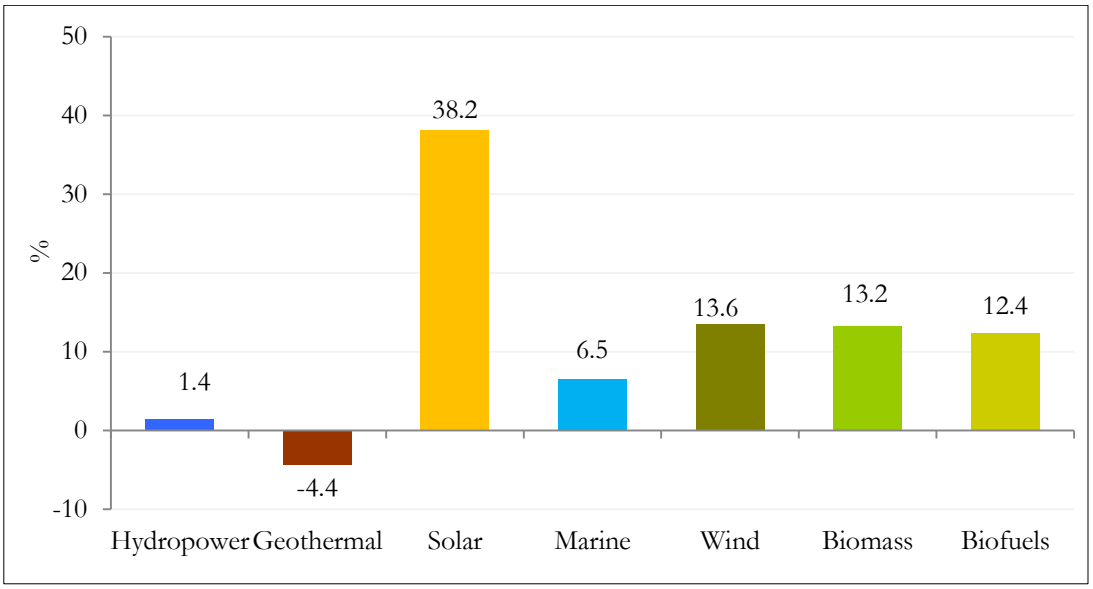

Figure 7. Relative increase of renewable technologies in total RES contribution, 2010

Germany has reported for both years the highest total RES generation with respectively 908 PJ (21.7 Mtoe) and 1052 PJ (25.1 Mtoe) with a relative increase of almost 16% (144 PJ or 3.4 Mtoe). France follows Germany with 817 PJ (19.5 Mtoe) in 2009 and 884.5 PJ (25.1 Mtoe) together with Sweden that reported 663 PJ (15.8 Mtoe) in 2009 and 722 PJ (17.2 Mtoe) in 2010 (Figure 8).

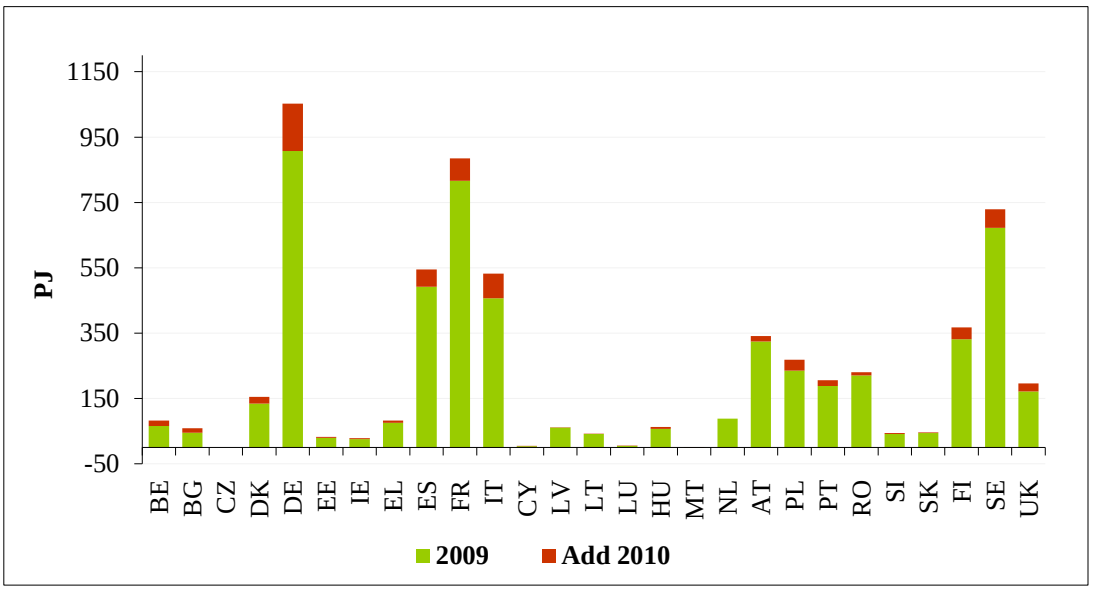

Figure 8. Total RES generated in EU 27, 2009-2010

RES heating and cooling

Contribution of RES to energy consumed in the heating and cooling sector in 2010 increased to 14.4% from 9.3% in 2005. In 2020 contribution of renewable energy in this sector is expected to reach 21.3%. The highest RES share in heating and cooling sector in 2010 was found in Sweden with 65.3% followed by Finland with 46.4% and Latvia with 43.8% (Figure 9).

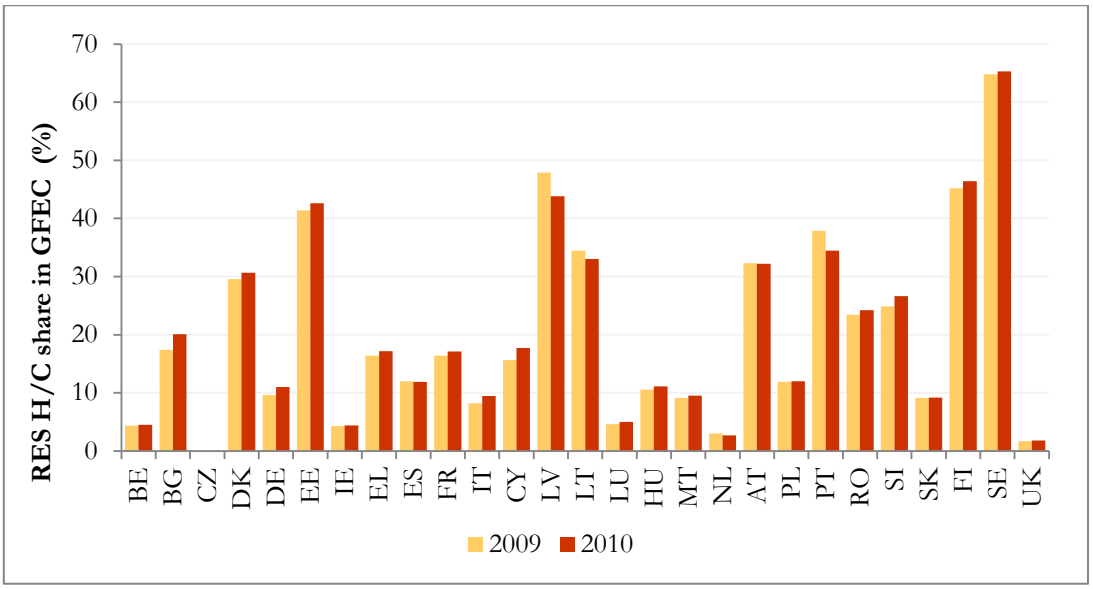

Figure 9. RES H&C share in GFEC in EU 27, 2009-2010

The overall renewable energy contribution in heating/cooling sector amounted to 3379.8 PJ (80.7 Mtoe) in 2010 where biomass was the main contributing technology with 92% corresponding to 3112.5 PJ (74.3 Mtoe), followed by heat pumps with 5.5% (182.6 PJ or 4.4 Mtoe), solar with 1.9% (62.7 PJ or 1.5 Mtoe) and geothermal with ~ 0.8% (22.2 PJ or 0.5 Mtoe).

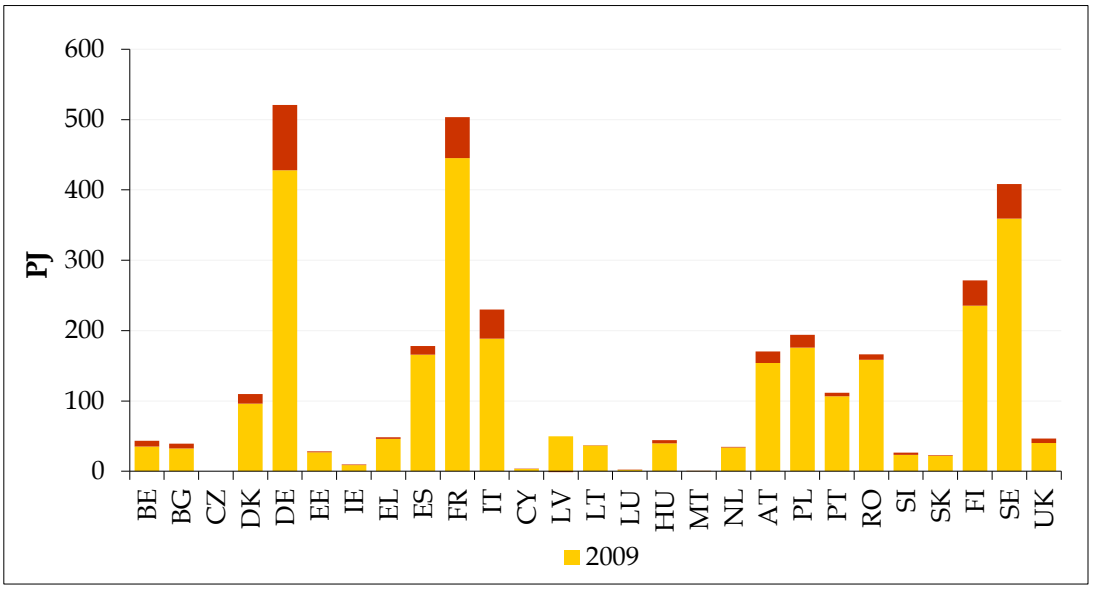

Figure 10. RES H&C in EU 27, 2009-2010

France reported the highest absolute amount of renewable energy in heating and cooling for year 2009 with 445.4 PJ (10.6 Mtoe) and the highest share (15.3%) while it was Germany that had the highest amount of renewable energy contribution in 2010 with 521 PJ (12.4 Mtoe) and the highest share as well (15.5%) (Figure 10).

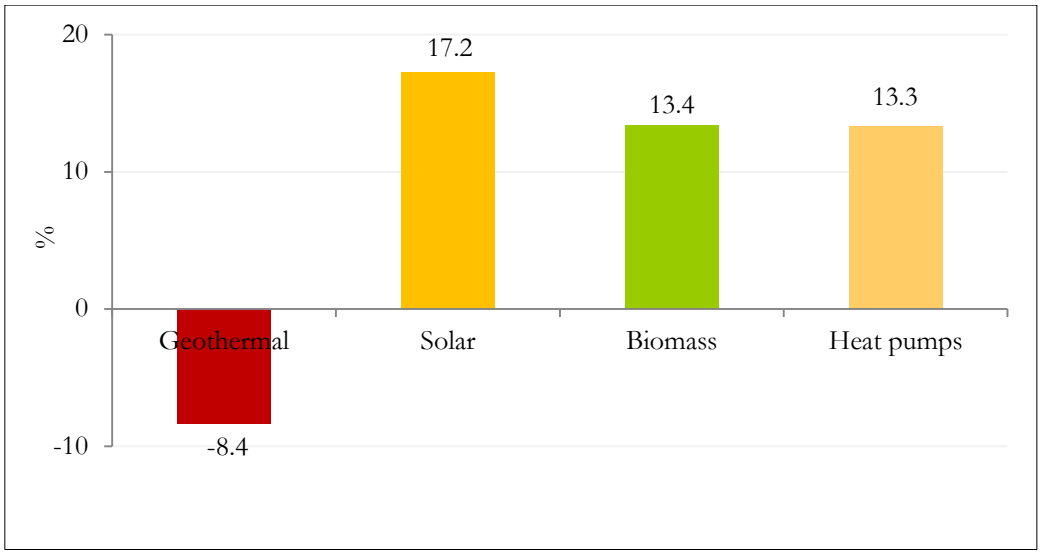

Figure 11. Relative increase of renewable technologies in H&C sector, 2010

Solar thermal reached in 2010 62.7 PJ (1.5 Mtoe) showing the highest relative increase from 2009 in the sector with 17.2%. Biomass in 2010 amounted to 3112.5 PJ (74.3 Mtoe) with a relative increase equal to 13.4%. Renewable energy from heat pumps in 2010 reached 182.6 PJ (4.4 Mtoe) with a 13.3% increase from 2009. Geothermal thermal had in 2010 the highest relative decrease from 2009 with 8.4% reaching only 21.5 PJ (0.5 Mtoe) (Figure 11).

RES electricity

RES electricity share in gross final energy consumption EU 27 increased from 14.7% in 2005 to 19.7% in 2010. In 2011[24] the RES electricity share was reported to 20.44% and it is projected to reach 33.8% in 2020. Renewable electricity in 2010 amounted to 641.7 TWh (2310.5 PJ or 55.2 Mtoe).

Austria reported in both 2010 and 2011 the highest RES share in the electricity sector with respectively 65.3% and 55.23% followed by Sweden (56% and 58.72%), Latvia (42.1% and 41.93%), Portugal (41.2% and 43.62%) and Slovenia (32.2% and 26.2%) (Table 2).

[24] Source: Eurostat table tsdcc330

Table 2. RES-E share in GFEC, 2009-2011

	2005	2009	2010	2011[23]
BE	2.70	6.33	6.97	9.04
BG	8.40	11.40	12.00	9.8
CZ[25]	3.40	7.40	8.00	10.3
DK	26.80	28.87	31.04	38.81
DE	10.20	17.40	18.40	20.35
EE	1.20	6.10	10.40	12.64
IE	6.90	13.70	14.80	19.4
EL	8.03	11.04	12.38	12.99
ES	18.40	27.20	29.20	30.18
FR	13.50	15.00	14.70	12.84
IT	16.29	18.81	20.09	23.64
CY	0.00	0.60	1.40	2.53
LV	44.90	42.00	42.10	41.93
LT	4.00	5.90	7.40	9.63
LU	3.20	4.10	3.80	2.95
HU	4.30	6.96	7.09	6.35
MT	0.00	0.02	0.08	0.0
NL	6.00	9.10	9.70	10.09
AT	59.80	67.40	65.30	55.23
PL	0.00	5.90	6.70	8.3
PT	29.30	38.40	41.20	43.62
RO	30.08	33.46	32.06	27.05
SI	28.50	33.80	32.20	26.2
SK	16.70	18.90	18.60	17.01
FI	27.00	27.20	27.60	27.65
SE	50.90	58.20	56.00	58.72
UK	4.70	6.60	7.40	9.2
EU 27	14.65	19.09	19.73	20.44

Solar technology showed in 2010 the sharpest increase in electricity generated from renewable: 60% compared to 2009 with its share in renewable electricity moving from 2.4% in 2009 to 3.5% in 2010. Nevertheless, hydropower remained the leading technology in this sector with 333.7 TWh (1201.4 PJ) with a contribution of 52% of the overall renewable electricity in 2010 and with an increase of 1.4% from 2009. Wind contribution in renewable electricity generation changed from 23% in 2009 to 24.2% in 2010 increasing with 13.6%. Biomass increased in 2010 with 12.4% compared with 2009 reaching 437.2 PJ (10.4 Mtoe).

[25] Data on RES-E share for 2009 and 2010 are reported from CZ in its Progress Report

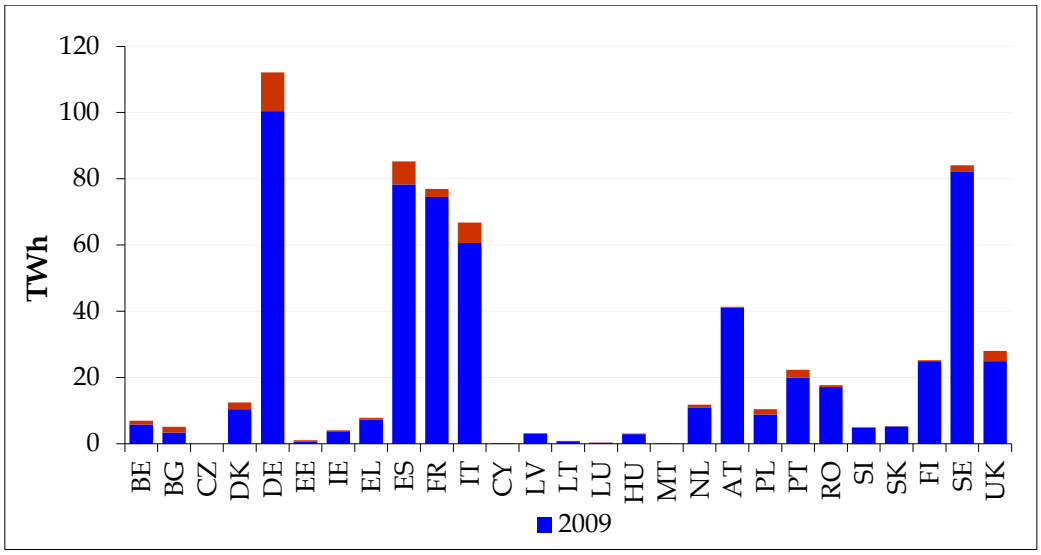

Figure 12. RES electricity generated in EU 27, 2009-2010

Germany reported the highest absolute RES contribution in electricity sector in both 2009 and 2010 with respectively 100.5 TWh (361.7 PJ or 8.6 Mtoe) and 112 TWh (403.7 PJ or 9.6 Mtoe), followed by Sweden with 82.3 TWh (296 PJ or 7.1 Mtoe) and 84.1 TWh (302.9 PJ or 7.1 Mtoe) and Spain with 78.2 TWh (281.7 PJ or 6.7 Mtoe) and 85.3 TWh (307 PJ or 7.3 Mtoe). Germany also had the highest additional RES contribution for year 2010 with 11.7 TWh (42 PJ or 1 Mtoe) followed by Spain with 7 TWh (25.3 PJ or 0.6 Mtoe), Italy with 6.1 TWh (22.2 PJ or 0.5 Mtoe) and United Kingdom with 3.1 TWh (11.2 PJ or 0.27 Mtoe).Contribution of Germany, Sweden, Spain, France and Italy in the total RES in electricity sector remained almost 67% in both years (Figure 12).

RES transport

Contribution of RES[26] transport in gross final energy consumption increased from 2% in 2005 to 4.8% in 2010. Total RES energy contribution with single counting in transport sector reached 555.8 PJ (13.3 Mtoe) in 2010 with a significant increase from 2005 (125.5 PJ) with an average annual growth rate of 68.6 %.

According to Directive 2009/28/EC the contribution of renewables in transport sector should reach 10% in 2020. In 2010 multiple counting in transport sector reached 628.8 PJ (15 Mtoe) with a contribution in gross final energy consumption in this sector equal to 4.96%.

Total RES contribution with double counting in transport sector in 2010 amounted to 604.6 PJ (14.4 Mtoe) with an average growth rate of 50.7% from 2005 level.

Austria reported the highest RES share in transport sector in period 2009-2010 with respectively 8% and 7.9% followed by Sweden (6.9% and 7.3%), France (5.9% in both years), Germany (5.8% and 6.2%) and Poland (4.8% and 5.9%) (Figure 13).

[26] RES contribution in transport sector is generally reported here without double counting. According Article 5 of the Directive 2009/28/EC the contribution of RES in GFEC in transport sector includes double counting in order to reach the 20% target in 2020. The contribution of RES for 10% target in transport sector includes multiple counting.

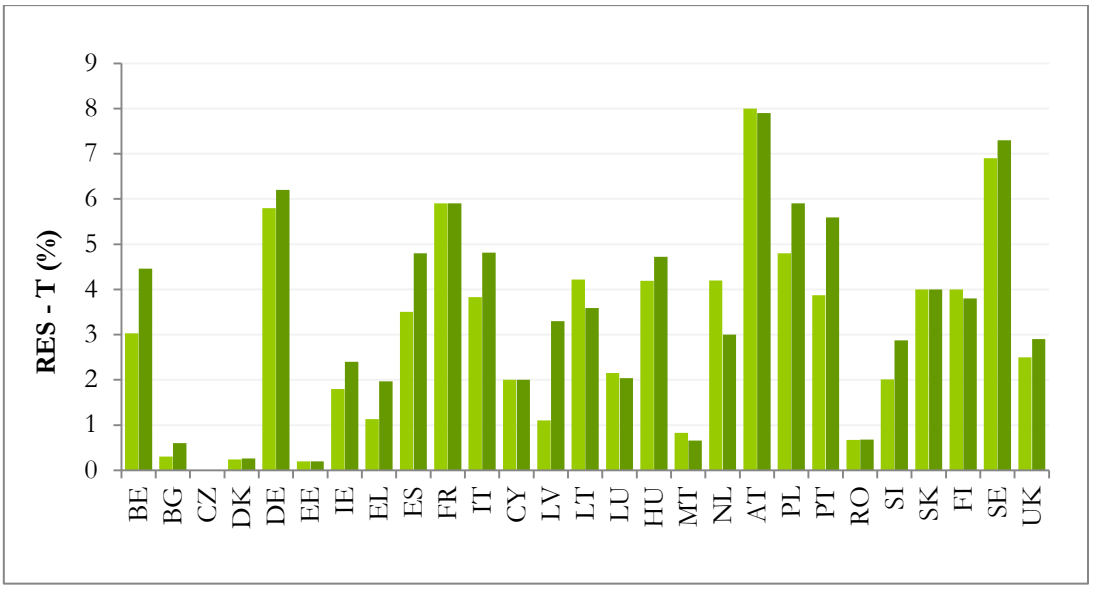

Figure 13. RES-T share in GFEC in EU 27, 2009-2010

Biodiesel had the highest contribution in renewable energy with single counting in transport sector in 2010 with 78% amounting to 433.5 PJ (10.3 Mtoe). Bioethanol presented in 2010 20.6% of renewable energy in this sector with 114.5 PJ (2.7 Mtoe) while other biofuels reached in 2010 a contribution of 1.4% in total biofuels with 7.8 PJ (187 ktoe).

Contribution of bioethanol and biodiesel in 2010 in renewable energy in transport sector with double counting was respectively 19% and 72%. Renewable electricity used in transport sector in this year reached 46.4 PJ (1.1 Mtoe) with a contribution equal to 7.7%. Contribution of other biofuels was marginal at 1.3%.

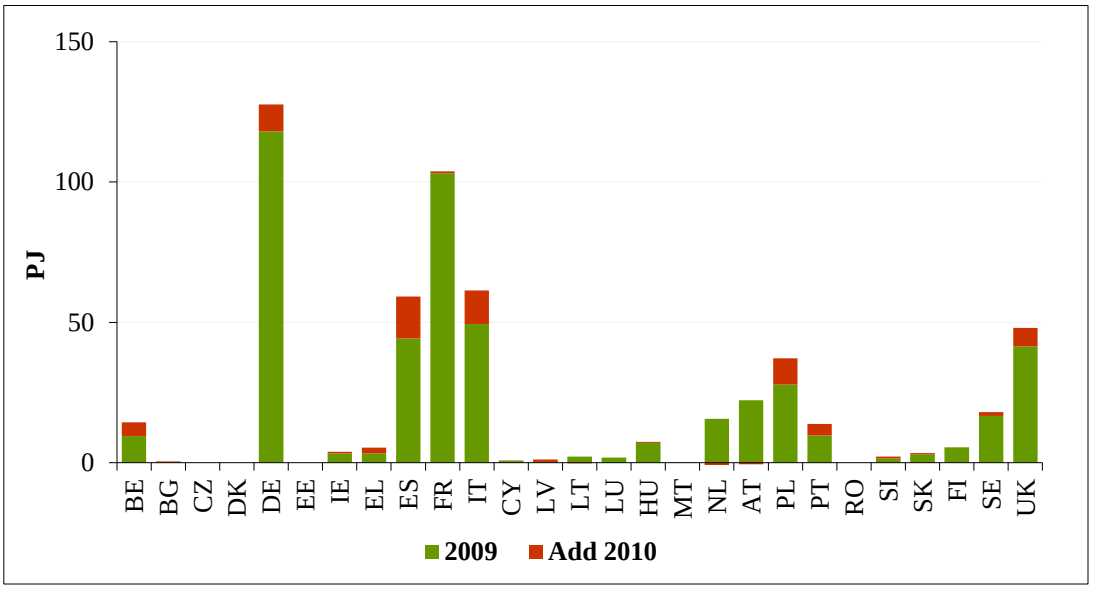

Figure 14. RES-T in EU 27, 2009-2010

Among all MS it was Spain that had in 2010 the highest absolute increase in renewable energy contribution in transport sector compared with 2009 with 15 PJ (0.36 Mtoe). Meanwhile it was Latvia that had the highest relative increase in 2010 compared with 2009 with 440% due to increase by ~ 10 times in biodiesel contribution. Germany had in both years the highest contribution in renewable energy in this sector with respectively 118 PJ (2.8 Mtoe) and 127.6 PJ

(3 Mtoe). France had almost 103 PJ (2.5 Mtoe) in both years followed by Italy with 49 PJ (1.2 Mtoe) in 2009 and 61 PJ (1.5 Mtoe) in 2010 (Figure 14).

Renewable energy contribution in transport sector in 2010 dropped only in three MS in comparison with 2009: in the Netherlands with -38.6% followed by Malta with -16.7% and Lithuania with -13.5%

Contribution of Germany, France, Italy, Spain and United Kingdom in total renewable energy in transport sector in EU 27 in 2010 accounted for almost 73%.

Trajectory targets

European Union reached in 2010 a total RES share in gross final energy consumption higher (12.6 %) than RES minimum trajectory share 2011/2012 (10.8%) and 2013/2014 (12%) being in good track for the achievements of 2020 target. Nevertheless it should be notice that in early years RES minimum trajectory shares, which represent the minimum RES share to be reach according to Directive 2009/28/EC, are set lower than the NREAPs targets.

European Union exceeded the 2011/2012 interim target since in 2009 reaching a total RES share equal to 11.9%. In 2011 European Union continue to increase the total RES share in gross final energy consumption reaching 13%, which is higher than both 2011/2012 and 2013/2014 interim targets (Figure 15).

20 MS, except Ireland, Greece, Cyprus, Malta, the Netherlands and United Kingdom, have reached their RES minimum trajectory share target for 2011/2012 since in 2009. In 2010 only Ireland, France, Latvia, Malta, the Netherlands and United Kingdom didn't exceeded this target. These MS will need to make additional efforts in order to be in good position to reach their 2020 targets.

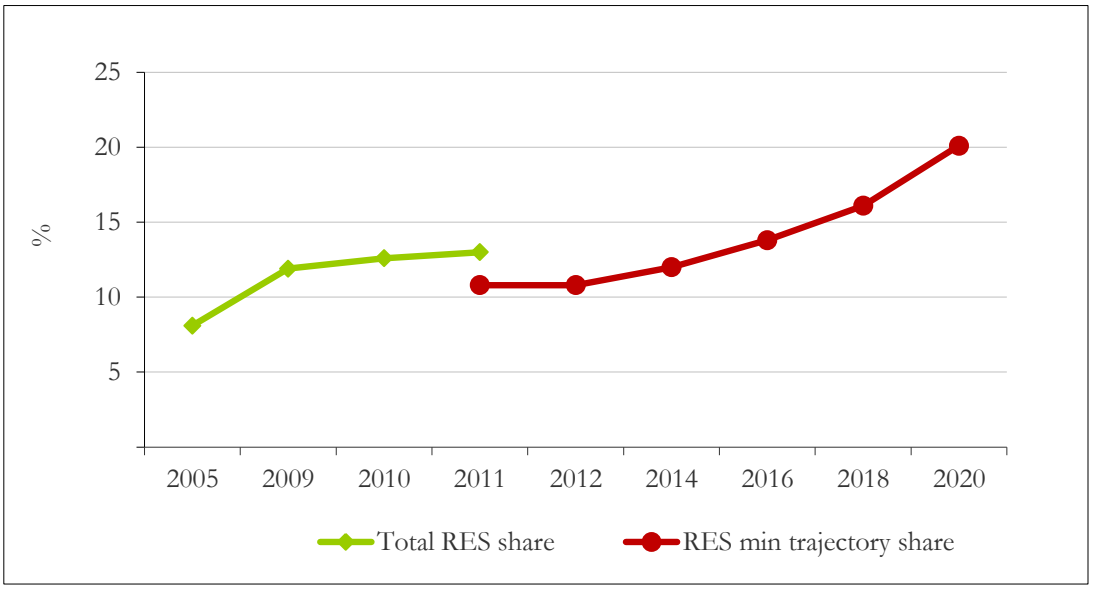

Figure 15[27]. Total RES share development in European Union, 2005-2020

More than half of MS reached in 2010 a total RES share in gross final energy consumption higher even than RES minimum trajectory share 2013/2014 target being in good track for 2020 targets if they will continue to keep this trend (Figure 16).

[27] Sources: NREAPs, Progress Reports and Eurostat table t2020_31 (EU 27 2011 total RES share)

Sweden had in 2010 the highest exceedance from RES minimum trajectory share 2011/2012 and 2013/2014 with respectively 6.2 and 5.6 percentage points. Austria exceeded in 2010 both these interim targets with 5.4 and 3.5 percentage points). Estonia had in 2010 an absolute exceedance from these interim targets equal to 4.6 and 3.9 percentage points. Latvia had the highest negative difference from both RES minimum share 2011/2012 and 2013/2014 targets with respectively 1.6 and 2.3 percentage points (Figure 16).

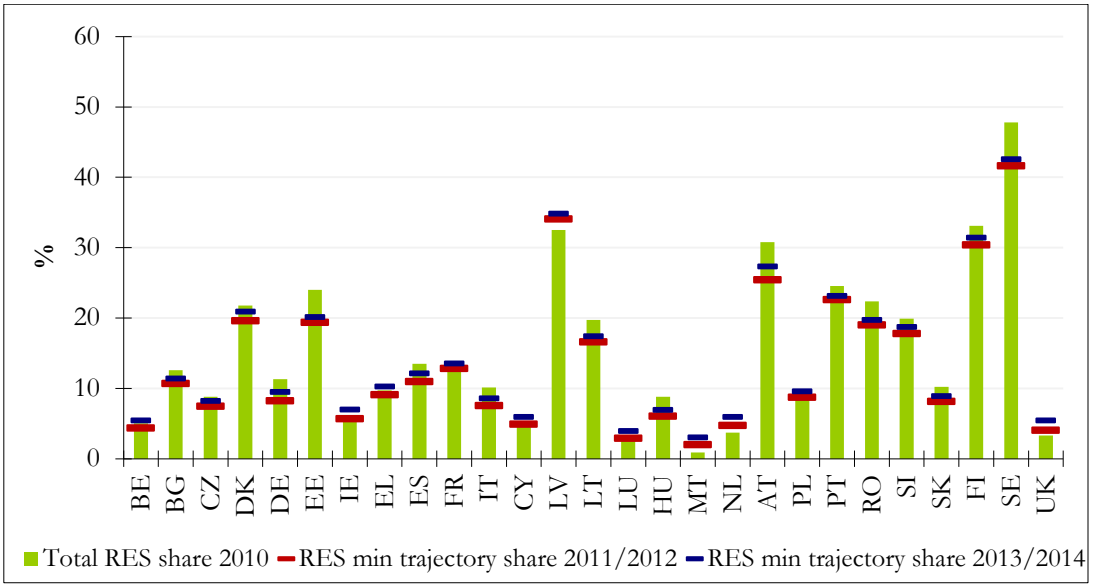

Figure 16. 2010 total RES share, RES min trajectory share for 2011/2012 and 2013/2014

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[3]. Eurostat 2012, last access May 2013. http://epp.eurostat.ec.europa.eu/

LIST OF ABBREVIATIONS

EU	European Union
US	United States of America
European Union Member States in official order	
BE	Belgium
BG	Bulgaria
CZ	Czech Republic
DK	Denmark
DE	Germany
EE	Estonia
IE	Ireland
EL	Greece
ES	Spain
FR	France
IT	Italy
CY	Cyprus
LV	Latvia
LT	Lithuania
LU	Luxembourg
HU	Hungary
MT	Malta
NL	Netherlands
AT	Austria
PL	Poland
PT	Portugal
RO	Romania
SI	Slovenia
SK	Slovakia
FI	Finland
SE	Sweden
UK	United Kingdom

Companies and Organisations	
BNEF	Bloomberg New Energy Finance
BTM	BTM Consult
CWEA	Chinese Wind Energy Association
EPIA	European Photovoltaic Energy Association
EWEA	European Wind Energy Association
GWEC	Global Wind Energy Council
JRC	Joint Research Centre
Units:	
k	kilo (10^3)
M	mega (10^6)
G	giga (10^9)
T	terra (10^{12})
P	peta (10^{15})
E	exa (10^{18})
J	Joule
toe	tonnes oil equivalent
W	Watt
Wh	Watt hour
Wp	Watt peak
Other terms	
BOS	balance of systems
EBIT	earnings before interest and tax
O&M	operation and maintenance
PTC	production tax credit

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Abstract

Penetration and deployment of some key renewable energy sources in Europe is analysed on the basis of the latest available data and statistics.

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As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

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